

SAE

Journal

MAY 1959

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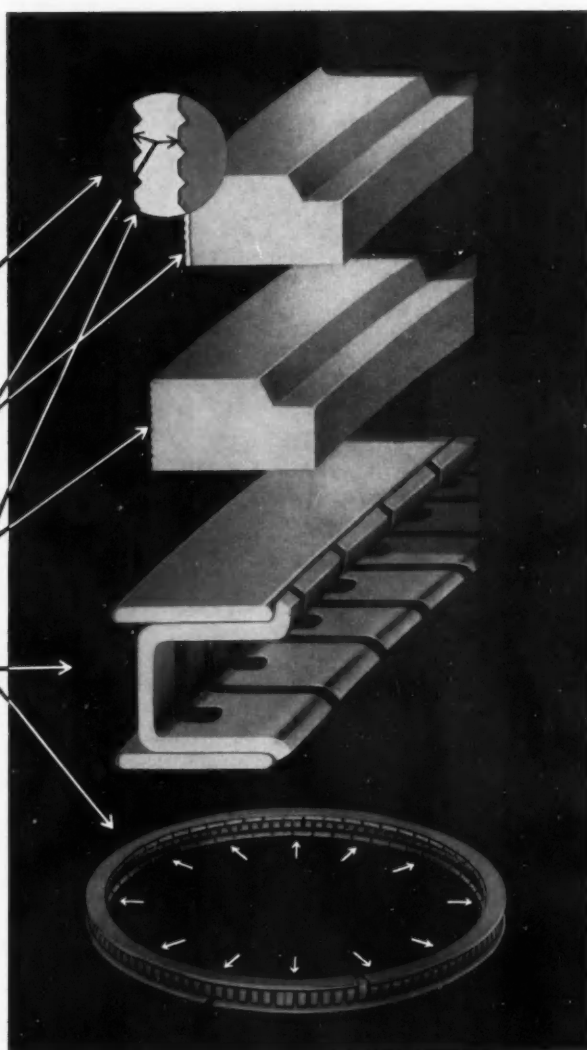
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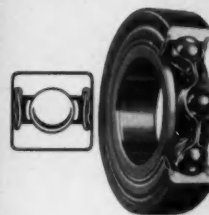
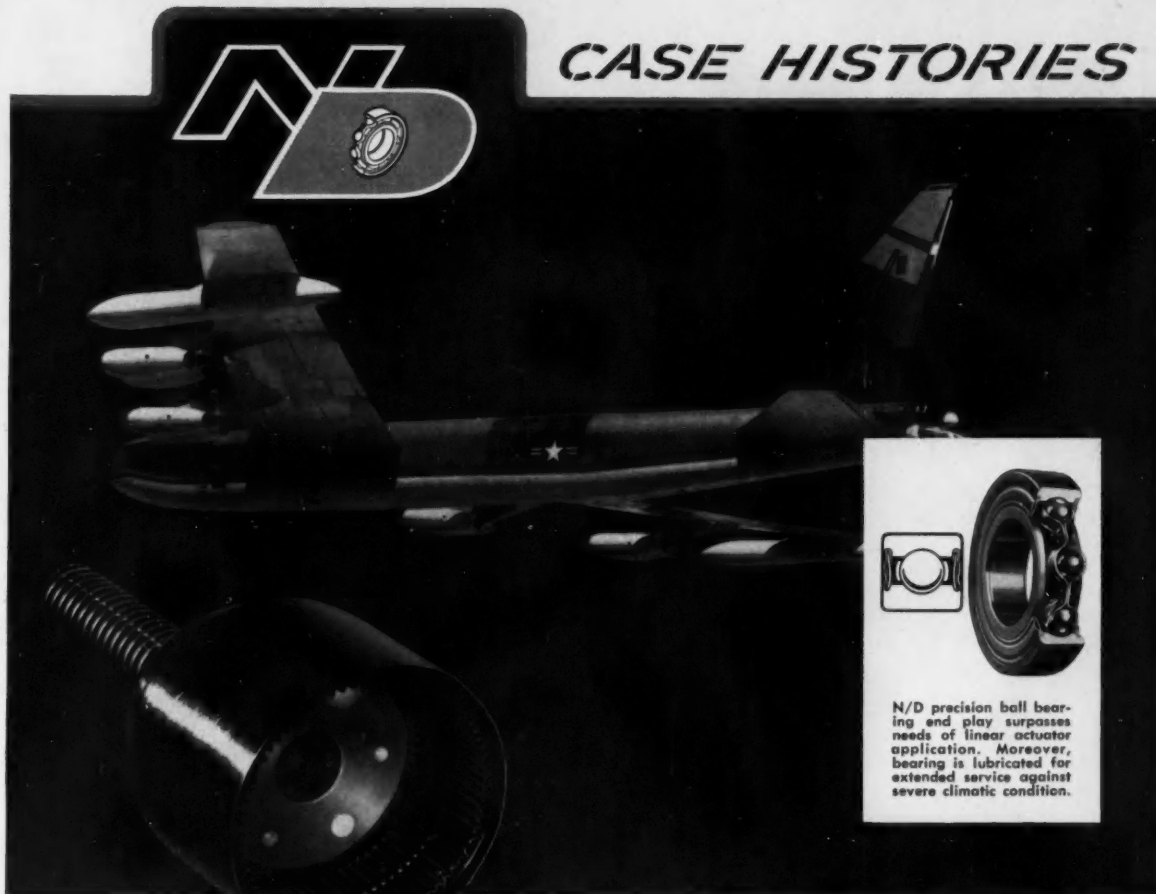
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SAE JOURNAL, MAY, 1959



CASE HISTORIES



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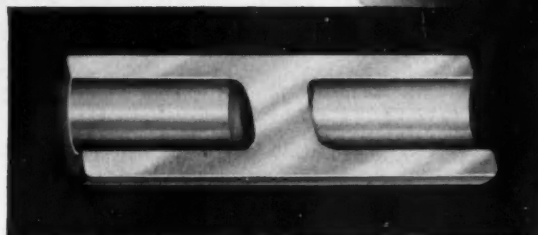
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AIRCRAFT

Role of Helicopter, R. S. ANGSTADT. Paper No. 15T. Evaluation of helicopter as transportation means between city center and airport; experience made by Chicago Helicopter Airways with scheduled service over triangular route pattern linking Midway Airport, downtown Chicago and O'Hare Field; chart shows number of revenue helicopter passenger movements between Midway Airport and downtown Chicago per 10,000 airline passenger movements at Midway; time-cost relationship, performance, and utilization levels presented.

Development of Piasecki "Sky-Car", F. N. PIASECKI. Paper No. 10V. Outline of basic flying platform concept employing ducted-propeller principle; advantages are that thrust can be increased for same propeller diameter and power input and that shroud acts as protection to blades; details of Piasecki Model 59-K flying platform research vehicle; test results of full-scale ground test rig, and investigation of control reactions by use of synthetic analog methods; taxi and free flight tests; military and civil applications.

Some of Needs of Modern General Aircraft and Some of Possible Answers, W. P. LEAR. Paper No. S150. Reference is made to light aircraft, medium priced, within reach and use of small businessmen; needs outlined with respect to radio communication and navigation equipment, autopilots, flight instrument, etc; suggestions made relating to possible arrangement of single twin engine configuration in nacelle of conventional single engine airplane adapted to single twin principle.

GROUND VEHICLES

Catalytic Oxidation of Automobile Exhaust Gases — Evaluation of Houdry Catalyst, G. J. NEBEL, R. W. BISHOP. Paper No. 29R. Evaluation of experimental lead-resistant catalyst developed by Oxy-Catalyst, Inc., to control

emission of hydrocarbons from automobiles was undertaken by General Motors; two passenger cars were equipped with catalytic converters containing Houdry catalyst; first car was standard production car; second car was equipped with special carburetor to minimize emission of oxides of nitrogen; results obtained; charts and tables.

Development of Catalytic Converter for Oxidation of Exhaust Hydrocarbons, R. T. VANDERVEER, J. M. CHANDLER. Paper No. 29S. System, developed by Ford Motor Co., which uses vanadium pentoxide on alumina as catalyst; possible solutions to mechanical problems associated with catalytic converters such as introduc-

tion of secondary air, excessive exhaust system back pressure, attrition loss of catalyst material, and exhaust system noise; performance evaluations and smog chamber tests; overall operating efficiencies of 60-73% can be expected; unsolved problems.

Application of Vanadia-Alumina Catalysts for Oxidation of Exhaust Hydrocarbons, W. A. CANNON, C. E. WELLING. Paper No. 29T. Experimental observations on particular catalyst system, developed by Ford Motor Co.; techniques used and data presented; thermal stability of aluminas and deposition of lead in fixed beds are treated in detail with objective that information developed will have extensive application to other catalyst sys-

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tems and devices for exhaust treatment which may be studied; tables. 24 refs.

Homogeneous Reaction Kinetics and Afterburner Problem, S. L. RIDGWAY. Paper No. 29U. Possibility of maintaining combustion reaction by temperature alone is considered as solution to problem of unburned fuel and oxides of nitrogen in automobile exhaust; mixing of exhaust gas with ade-

quate air, maintained at sufficient temperature for sufficient time for completion of combustion is suggested; behavior of reaction rate; tests with Mark III afterburner on 1955 Chevrolet car show that system maintains itself if concentration of CO during cruise is above 1.2%.

Maintenance and Automobile Exhaust, W. S. FAGLEY, M. V. SINK, C. M. HEINEN. Paper No. 29V. Progress report on possibilities for hydrocarbon reduction by proper maintenance, which represents portion of Chrysler's contribution to Automobile Mfrs. Assn. program on vehicle combustion products; it is found that 1956 Field Survey data show hydrocarbon and carbon monoxide emissions much higher than those from periodically maintained Engineering Service Fleet; reduction of such emissions of order of 60% appear to be possible by regular maintenance.

Development of "RAT", L. J. STY-PINSKI. Paper No. S149. Developed in 1956 by Canadair Ltd to requirements of Canadian Army, light tracked vehicle provides prime mover capable of carrying load and towing infantry sleds and toboggans over snow covered terrain; it can cross rivers and lakes, is suitable for limited amphibious landings and has ground pressure of 1/2 lb/sq propulsion system consists of 35-hp engine, power transmission and tracks; steering principle on basis of articulation; parachute aerial delivery of RAT is possible.

Digital Computer Analysis and Interpretation of Turbo-charged Diesel Engine Performance, H. A. COOK. Paper No. 3S. Application of cycle analysis to engine development program at Thompson Products, Inc.; design concepts in adapting turbocharger to match to exhaust of V-8 diesel engine; correlation of calculated and test results; study of some design or operating parameters; design of intake and exhaust manifold; evaluation of new design concepts in planning stage.

Arizona Summer Testing of Automotive Air Conditioning Correlated with Laboratory, J. D. LOVELEY, P. W. WYCKOFF. Paper No. 22R. Features of hot wind tunnel used at Chrysler Corp. to simulate Arizona weather conditions; most difficult three variables to simulate were: air velocity over car body, solar radiation, and air infiltration; development of "U" factor concept expressing car body heat transfer characteristic and its calculation; factors affecting air conditioning unit performance; effect of air infiltration during recirculating air operation.

Climatic Testing Indoors — Ford's Hurricane Road, W. A. McCONNELL. Paper No. 22S. Construction details of second wind tunnel, designed for weather simulation; routine test procedures representative of types of testing performed; example of testing engine cooling system for commercial trucks; development of cooling procedures for passenger car; means of air temperature control; tests of car heater and defroster systems and miscellaneous tests; data handling system and typical test log sheet; arrangement of wind tunnel and equipment employed.

Testing with Controlled-Weather Chassis Dynamometers, G. W. STANKE, H. C. SUMNER, H. A. TOLMIN. Paper No. 22T. Details of 3-room controlled-weather room facilities and some of tests especially designed at Research and Development Dept. of Ethyl Corp.; capabilities of chassis dynamometers; weather conditions are duplicated by controlling air temperature, humidity, and velocity; cor-

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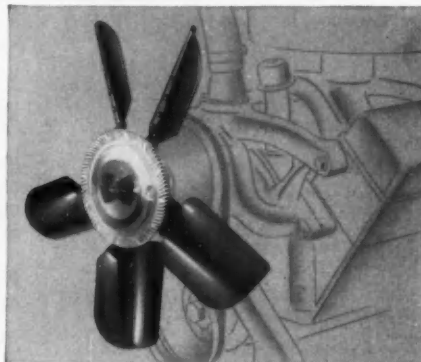


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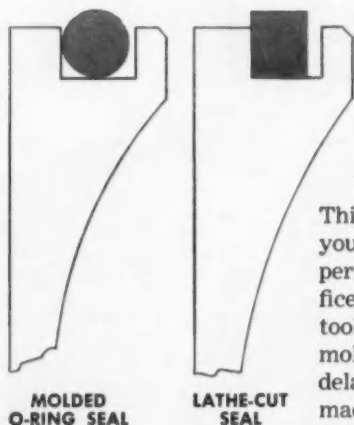
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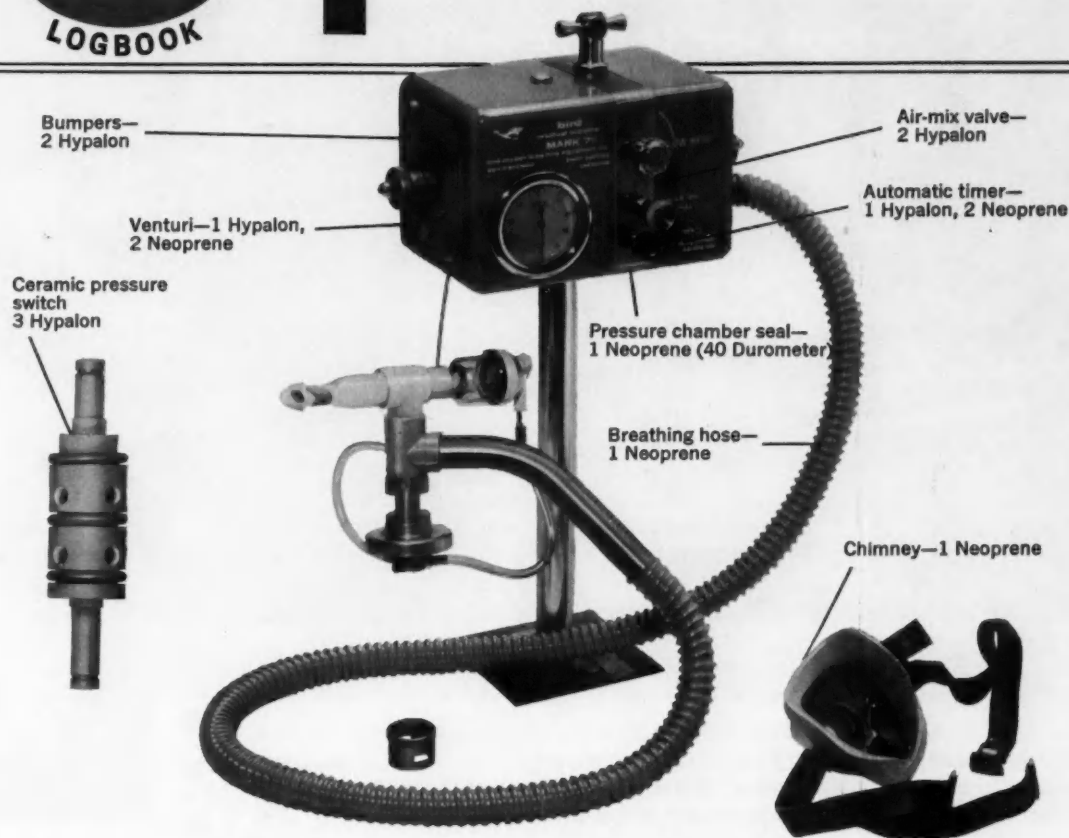
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These are some of the requirements National® O-Rings meet in the revolutionary new Bird MARK 7® Respirator. Introduced little over a year ago, the compact, light-weight Bird MARK 7 is in use throughout the Free World and is hailed by anesthesiologists, surgeons and hospitals as a major advance in therapy for serious disorders such as polio, pneumonia, other lung disorders and coronary problems affecting breathing.

National Welding Equipment Company, makers of the Bird respirator, state that the high order of depend-

ability could not have been achieved without National Hypalon O-Rings. In addition to their stability vs. oxygen, moisture, medications and gases, the Hypalon rings are rugged, and are not damaged when press-installed over extreme-hardness ceramic bushings.

A total of 15 National O-Rings are used in the Bird MARK 7. Nine are Hypalon, five are conventional 70 Durometer neoprene rings and the 15th is a large 40 Durometer Neoprene ring used as a static seal between the pressure chamber and main chassis.

National O-Rings are available in standard sizes, commercial grade, or in special compoundings including Hypalon. For details or O-Ring engineer assistance, call the nearest National Seal engineer. Look in the Yellow Pages, under Oil Seals or O-Rings.

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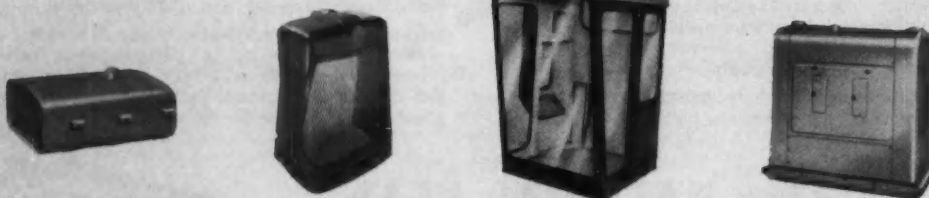
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Now—a tire that ends roadblocks in vehicle design!



Photo courtesy United Fruit Company, Boston, Mass.

Bringing bananas out of remote tropical groves used to be a costly, time-consuming job until the unique vehicle above was developed. Secret of this carrier's amazing mobility is the Terra-Tire—barrel-shaped, low-pressure pneumatic tire by Goodyear. Virtually punctureproof, these axle-driven and axle-loaded tires *conform* to the ground contour rather than resist it. Result: they can traverse bumpy terrains with less jostling than other

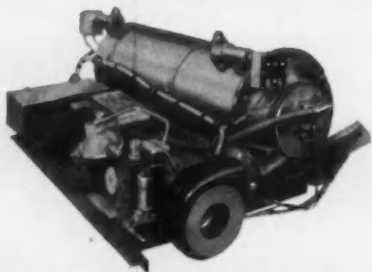
methods. Even loose sand and soil present no problem for the Terra-Tire. This makes them ideal for banana haulage. They don't need roads. They can roll right into backwoods areas. And the ride is so cushion-soft that the bananas aren't even bruised! These are just a few of the Terra-Tire advantages that are prompting unusual interest—and wide application—by design engineers.

Terra-Tire—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio



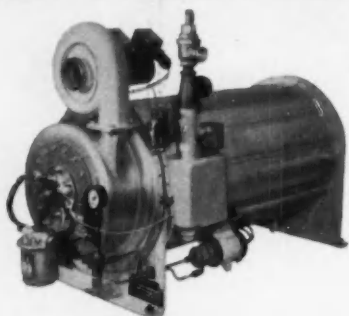
Where can Terra-Tires save for you? Designers: by designing vehicles *from the start* to utilize engineering advantages of Terra-Tire transportation, substantial savings in space and weight can be realized. For more information, contact Goodyear, Aviation Products Division, Akron 16, Ohio.

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for portable structures, large vehicles, and for heating decontaminants and cleaning fluids on mobile ice removal units.



1,000,000 Btu/hr Janitrol liquid heater

for missile fuel transfer operations, large portable structures, airlifted equipment. Approximately 18" in diameter, 47" high, weight: 260 lbs.

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Missile and aircraft support equipment builders use Janitrol *liquid* heater packages with little or no modification because they're designed for military applications. Meeting appropriate MIL specifications and fully qualified, they're available in outputs to 1 million Btu/hr. They provide any desired amount of heat up to rated output and automatically maintain constant temperatures.

As an example of acceptance, most Air Force crash-fire vehicles are equipped with one or more of these heaters, for engine, chemicals, cargo and crew space heating. Multi-fuel operation is standard, and they perform reliably in multiples for heat requirements which exceed the output of a single unit.

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Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio.



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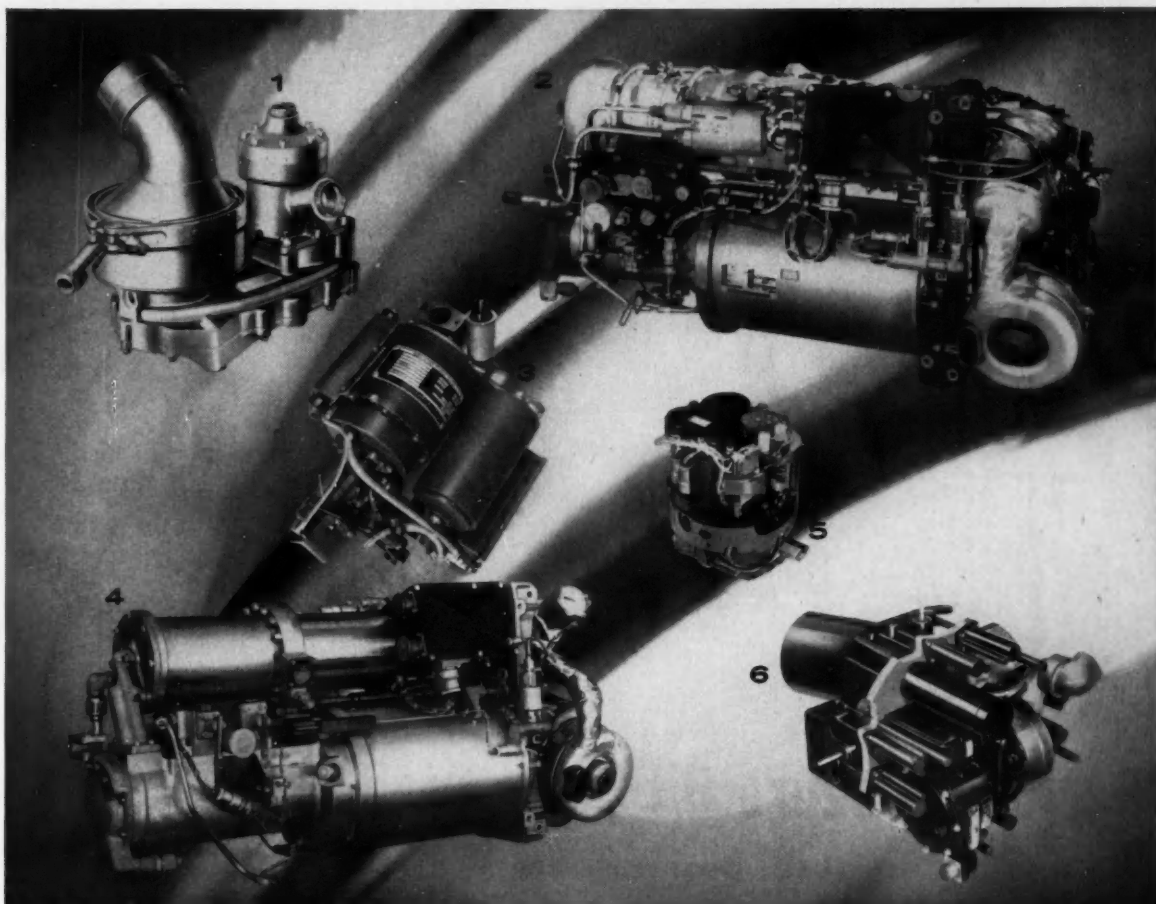
A+ felts are exclusive with American Felt Company. They are used to filter, to cushion, to seal, absorb, cover—and to decorate. They are made as soft as cashmere or as tough as hide. And in felt, the best guarantee of quality is the A+ hall-mark. American Felt Company perfected natural wool felts over half a century ago—and pioneered synthetic fiber felts.

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DELIVERED—thousands of missile APU's



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4. Liquid propellant—hydraulic and electric output 5. Solid propellant—hydraulic and electric output
6. Solid propellant—hydraulic, electric and steering outputs

AiResearch has designed, developed, manufactured and delivered thousands of missile accessory power units. Extremely reliable and lightweight, these various solid and liquid monopropellant APU's are completely self-sustaining within the missile system. Designed to minimum space and weight requirements, they are built to withstand high G loading and severe temperature extremes.

The several units pic-

tured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as $\pm 1/2\%$. A significant advance in missile APU's is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing

a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery—the key component of its APU systems. Your inquiries are invited.

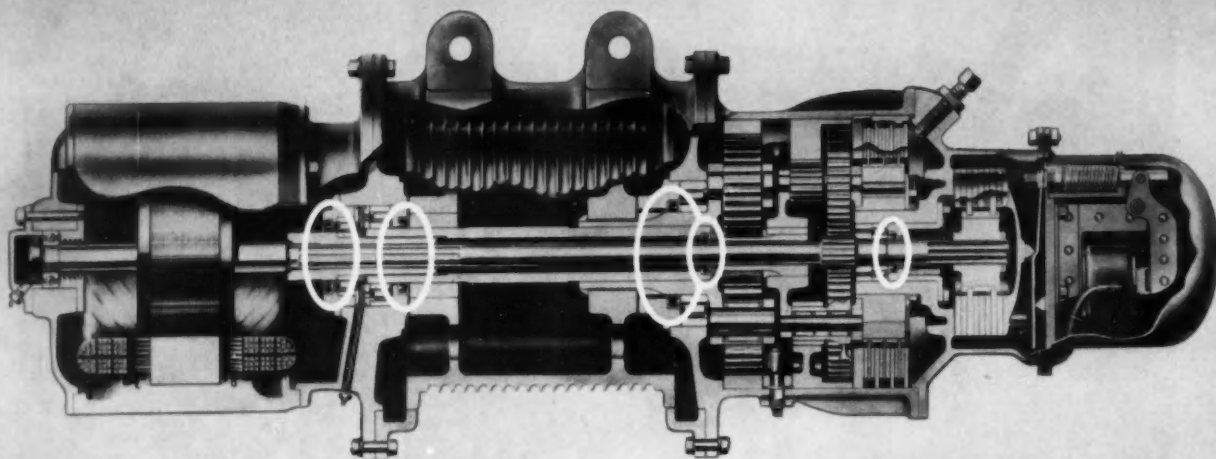
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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

MORE ABOUT THE GARLOCK 2,000



General-purpose KLOZURE Oil Seals (Model 63 cutaway right) afford complete protection at important bearing locations (circled above) on the Shepard-Niles "Liftabout" Hoist.

Garlock Kloxure^{*} Oil Seals

**assure durable, dependable
performance on tough sealing jobs**



Friction and bearing wear, hazardous to any industry, are especially harmful in materials handling. That's why Shepard-Niles and other leading crane and hoist manufacturers specify Garlock KLOZURE Oil Seals for complete bearing protection. Shepard-Niles "Liftabout" is typical of how Garlock KLOZURES not only exclude dust and foreign matter from bearings but also retain the important lubrication—both of which add to greater dependability during rugged hoist operation.

Designing Garlock KLOZURES into your equipment protects bearings with oil seals that are durable,

economical, and easy to replace. Garlock KLOZURES can be applied on low, medium, or high speed service. Whether your application is general-purpose in nature, or there's a specific job to be done, Garlock has a KLOZURE design for you.

KLOZURES are another of the Garlock 2,000 . . . two thousand types of packings, gaskets, and seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative.

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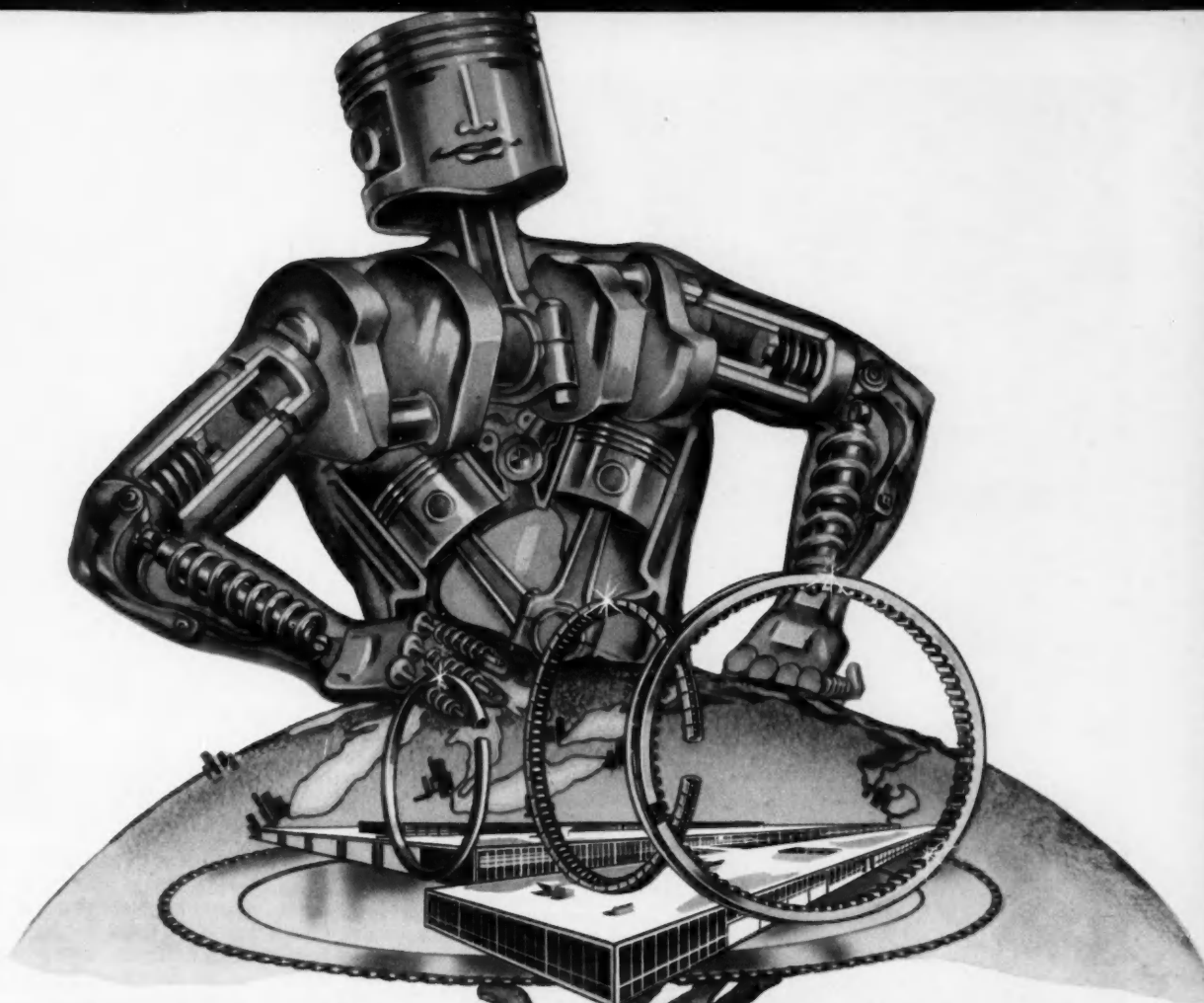
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*Yes...
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At Sullivan and St. Louis as well as at Manchester, we'd like you to see our RAMCO piston ring plants in action. Our new booklet "MOST MODERN RING PLANT" will give you a preview of what you will see when you visit these plants... why not write for a copy today?



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aluminum permanent-
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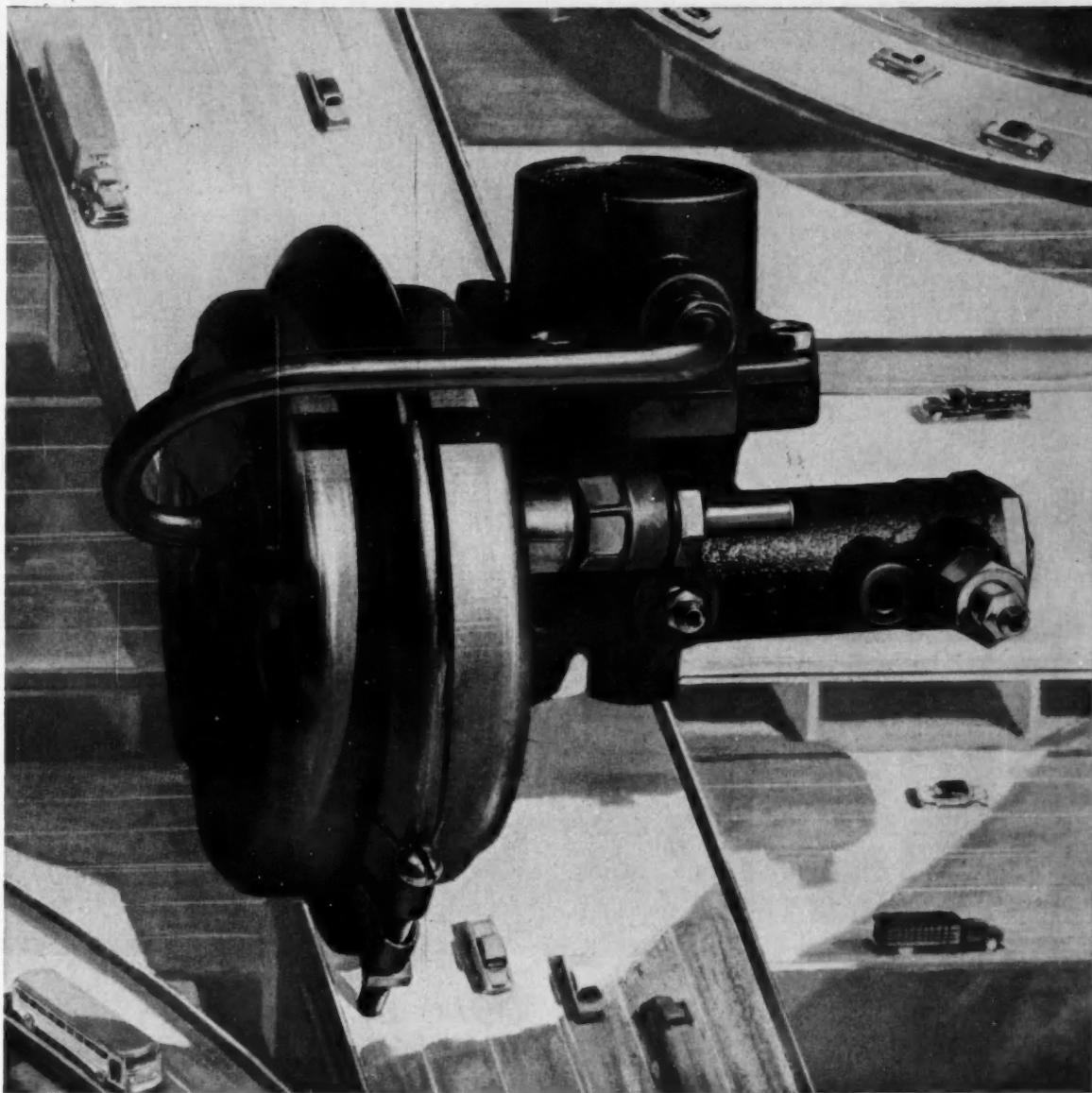
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 Equipment for the Transit industry
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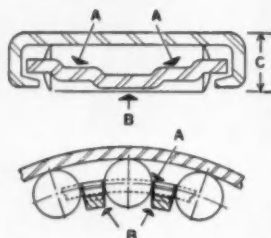
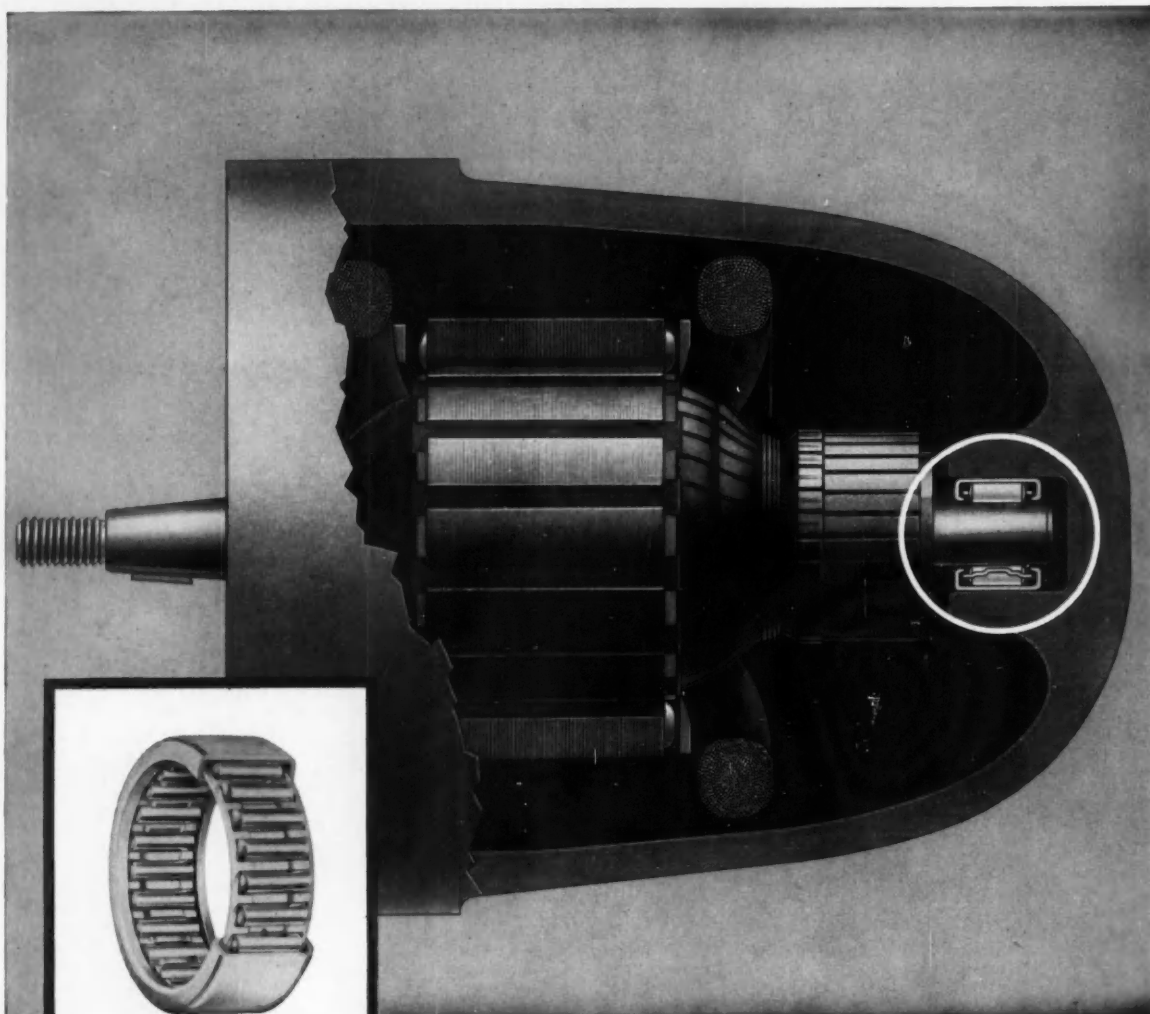
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- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Save up to 50% on armature bearing costs!

Low unit cost of the new Torrington Drawn Cup Roller Bearing reduces armature bearing cost as much as 50%. This unique bearing gives excellent service at high speed and permits prelubrication for life.

Test installations and service applications show the bearing performs efficiently at speeds up to 25,000 rpm in intermittent service of 1000 hours and more. In such service, initial lubricant lasts the life of the motor. Most applications require no seals. This, with the simplicity of housing design, contributes further to economy.

Designers are invited to evaluate the Torrington Drawn Cup Roller Bearing for such applications as generators, power tools, electric mixers, vacuum cleaners and other appliance motors where considerations of cost, speed, efficiency and light weight are paramount.

Servives of Torrington's engineering staff are offered to assist you in design developments of every type of electric motor. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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For Sake of Argument

Is Dictation Writing?

"Good reports aren't written . . . they're rewritten," John Riebel tells his engineering students at California State Poly. We think he is right.

The statement holds for most business writing . . . especially for dictated communications. Failure to recognize dictation as a form of speaking is responsible for much mediocre and tangential "writing."

Dictation is a major hurdle to clear writing for easy reading — for most of us. It just isn't natural to speak in the crisp, lean sentences which good business writing needs. Spoken, such sentences sound studied, stilted.

Best corrective to dictated-writing is to have dictated material come back for editing — and/or *rewriting*. (Re-dictating usually compounds the felony!)

This time-consuming corrective isn't always feasible, of course. It's appropriate only on pieces important enough to warrant the extra work. But seriously evaluating each case can bring surprises. Experimenters find themselves willing to classify a very few of their own communications as of little importance!

The transcript of almost any well-received speech emphasizes the dangers of dictation (a speaking form) as a writing tool. The good talk rarely makes a first-class article. (Nor does the well-written article usually make a first-class speech.)

Only as regards organization of ideas do written and spoken pieces have the same requirements. In both cases, statement of the main idea gives an effective start . . . makes it easier for *either* reader or listener to pigeon-hole subsequent ideas as they come along.

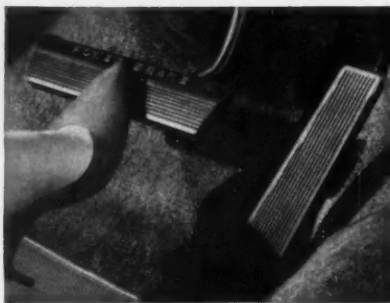
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New power to steer! Today's driver has greatly augmented ease of handling, control and assurance—thanks to Bendix® power steering. It has increased in popularity every year since its introduction, and today most new car buyers demand it.



New power to stop! Safety is multiplied many times for the driver of today's faster, more powerful automobile... by Bendix®-pioneered power brakes. Millions of car buyers each year "buy" this new and better concept in safety and better control.



Now—brakes that adjust themselves! This latest Bendix braking development adds the powerful sales appeal of economy to the tried-and-true one of safety. More cars every year have this new feature—it's only a matter of time until they all do.



Helping make each model year as dramatic as a year-long "Opening Night", the automakers are seconded by suppliers

like Bendix Products Division. While master carmakers and designers are concerning themselves with problems of total design and concept, specialists like Bendix Products Division, working in specialized areas such as steering and braking, create innovations and improvements that take their place in the total design yet, in their own right, are powerful interest creating salesmakers.

Three of the sales successes de-

veloped by Bendix Products Division are shown at the top of the page. These and many others are being demonstrated on the road every day by practically every car on the road—and by millions of new cars sold every year.

In developing features like these, Bendix Products Division benefits from the planning talents, the research skills, and the production know-how of its own engineering staff first... but also from the unique Research Division and the 24 divisions of the Bendix Aviation Corporation. Through the products of Bendix Products Division, these talents are available to you, too. Why not put them to work for you?



Testing Torque and Temperature! Research engineer checks various operating factors such as torque and temperature on a new brake design undergoing dynamometer test in Bendix Engineering laboratory.

Planning Committee in Session! Almost endlessly they debate two key questions: "Will it work?" and "Will it sell?" Here's just one of the thousand of technical and strategy meetings at all levels that precede the launching of a new Bendix product.

*REG. U. S. PAT. OFF.

Bendix PRODUCTS
DIVISION
South Bend, IND.



chips

from SAE meetings, members, and committees

PASSENGERS might appreciate humidification at high altitudes, but electrical components do not, according to C. H. Jackson of BOAC. U.S.A. competitors assume a dry atmosphere is acceptable—maybe this has something to do with home training—so BOAC will go slow with installation. Domestic plumbing gets worse at high altitudes, too, and seems to require the attention of the best engineering brains... which throws doubt on the practicability of supersonic transport.

COST OF MAINTENANCE and replacements during the life of military electronic equipment runs at least 10 times the original cost, equipment studies show.

WANT TO SCOOP THE U. S. GOVERNMENT? The first nuclear-powered surface ship—the USS Savannah—now under construction, will be commissioned in about two years. But, plastic scale models of the vessel are already available in toy shops, Dr. C. R. Lewis, chairman of the SAE Nuclear Energy Advisory Committee has discovered. Thus, the vessel can be sailed under reduced circumstances by any interested SAE member well in advance of the first Government operation.

FORD'S A. C. BODEAU offers as a simplified definition of ride—those motions “introduced to the passenger's torso through the car seat.” Motions and result-

ant forces acting on the human body are generally more influential than motions seen or heard. Motions experienced by the body through the car seat have an influence over those felt by the feet on the floor or pedals, the hands on the steering wheel, or the forearm on the arm rest.

OF ALL THE PEOPLE who have ever been born, one out of twenty are alive today, says H. D. Hall of GM's Process Development staff, quoting Dean Harrison of M. I. T.

BACTERIA CAN CAUSE SLUDGE FORMATION in stored JP-4 fuel. But 1.5-2% sodium or potassium tetraborate added to the water bottoms of the storage tanks will prevent the bacteria from multiplying... without affecting engine operation or harming engine components.

HYDROGEN, THE MOST POTENT CHEMICAL FUEL, can produce 80% more thrust per pound than petroleum fuels, and 20-30% more than boron fuels. That's why NASA is planning to use liquid hydrogen as fuel for the second-stage rockets of large earth satellites. The problems involved in handling and burning it smoothly are, however, expected to delay its use until 1960 or 1961. It reportedly never will be practical for military rockets because exhaustive preparations would be needed to get the engine combat-ready.

DRIVERS traveling at speeds below 40 mph are involved in accidents at a rate several times higher than those traveling at faster speeds shows a study covering 3.7 billion vehicle miles of travel by 290,000 drivers, and accidents involving 10,000 vehicles. Daytime involvement rate was lowest for speeds between 55 and 70 mph. Low horsepower cars show an exceptionally high involvement rate.

“PEOPLES PODS”—to ferry passengers from the terminal to waiting planes—are planned for Washington's new International Airport. These 80-passenger rolling ferries may cost \$100,000 or so a piece. But they will cost less than building a couple of miles of causeways and will save passengers from having to hike a half a mile or so from ticket counter to loading gate.

The pods will load from one end at second-story level of the terminal and lumber out to the aircraft. An adjustable snout at the other end, containing an extensible gangplank, will snug up to the aircraft's door so that passengers can walk aboard on the straight and level.

ACCIDENT INVOLVEMENT grows progressively worse with the age of the vehicle. Cars less than two years old are driven 50 million miles per fatal accident, while cars more than eight years old are driven only 21 million miles per fatal accident.

Coming? Central Hydraulics

A single universal fluid is the key
to the system development.

CENTRAL hydraulic systems may be on the way for passenger cars. Their aim: To relieve the ever growing burden of electrical accessory power and to reduce driver fatigue by expanding power assists. The possibility of such a system has already been emphasized by existing European production of a car with a central system. Key to the system is development of a universal fluid.

Equipment that potentially can be run by hydraulic power includes such things as:

- Brakes
- Steering
- Windshield wipers
- Window lifts
- Adjustable seats
- Convertible tops
- Starters
- Clutches
- Fuel pumps and injection equipment
- Air conditioning
- Suspension systems

Presently, some of these items already use hydraulic power . . . but not the same fluid.

Investigation by two SAE technical committees has revealed that brakes and power steering are the most critical applications. Low-temperature viscosity must be met to insure fast acting brakes at -40 F . . . and power steering imposes a high-temperature viscosity limitation to guarantee good fluid pumping. If these and other normal requirements of these two applications are met, fluid trouble will not beset any of the other power equipment.

stopping is safer and faster

Possible central hydraulic braking systems have the promise of shorter stopping distances than either the present manual- or vacuum-operated systems. Early tests, using similar conditions of cars and drivers, show some system-reaction-time improvement over vacuum and manual systems. These improvements are purely mechanical. They

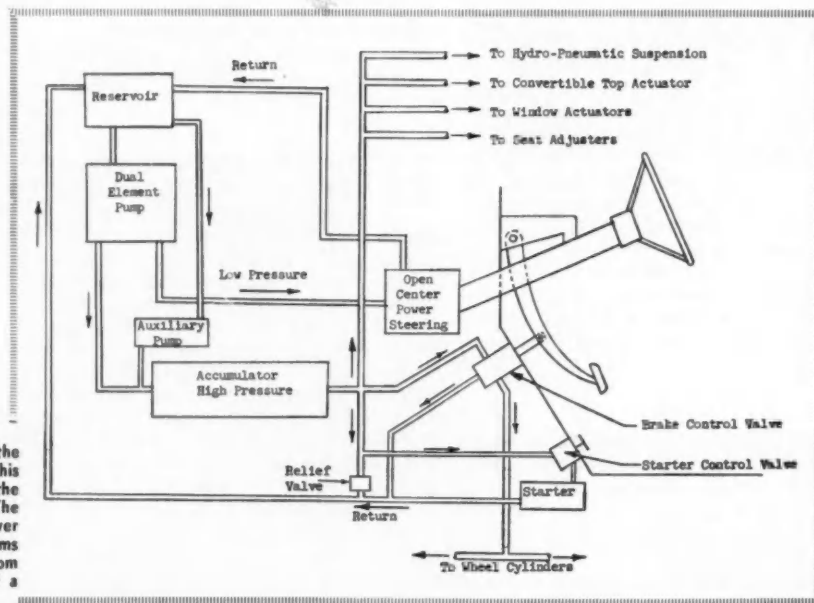
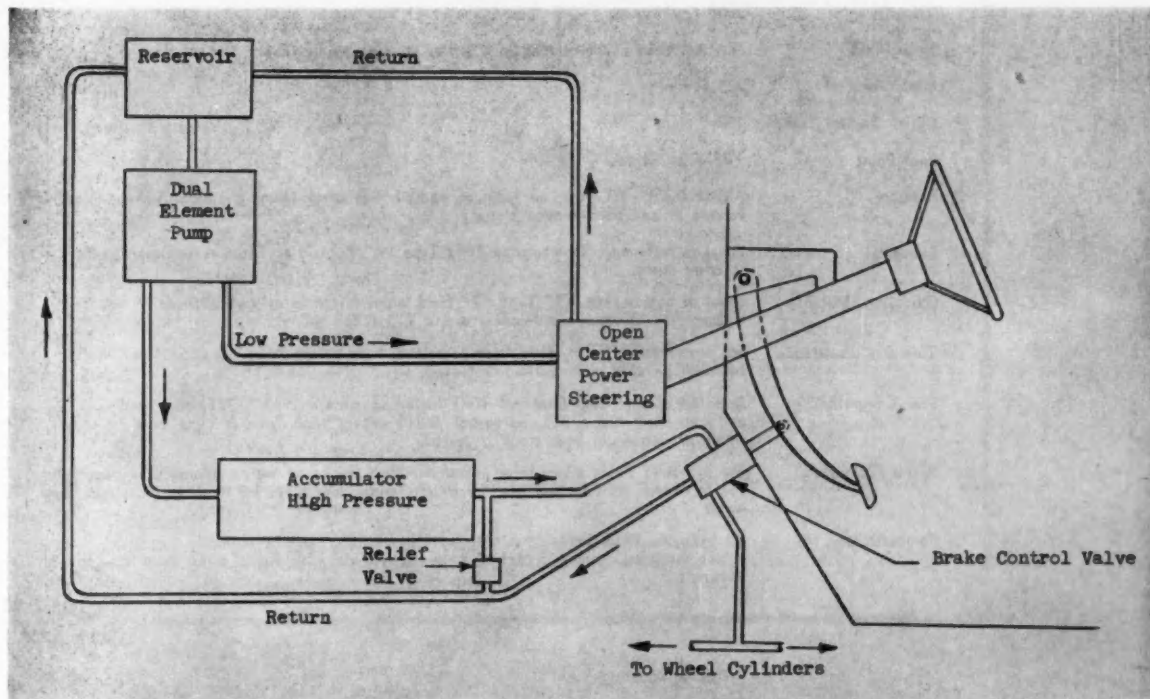


Fig. 2—When a starter is added to the system an auxiliary pump is needed. This covers the possibility of discharging the accumulator without starting the car. The auxiliary pump could be hand or power driven. In this or other complete systems the brake pressure can be isolated from the rest of the system by the use of a second accumulator.

for Passenger Cars



A SIMPLE CENTRAL HYDRAULIC SYSTEM (FIG. 1) could use a two piston pump and open center steering. This system will supply a small quantity of high pressure fluid for brake applications. Low pressure fluid is supplied for the power steering so that the fixed displacement pump will not overheat the fluid.

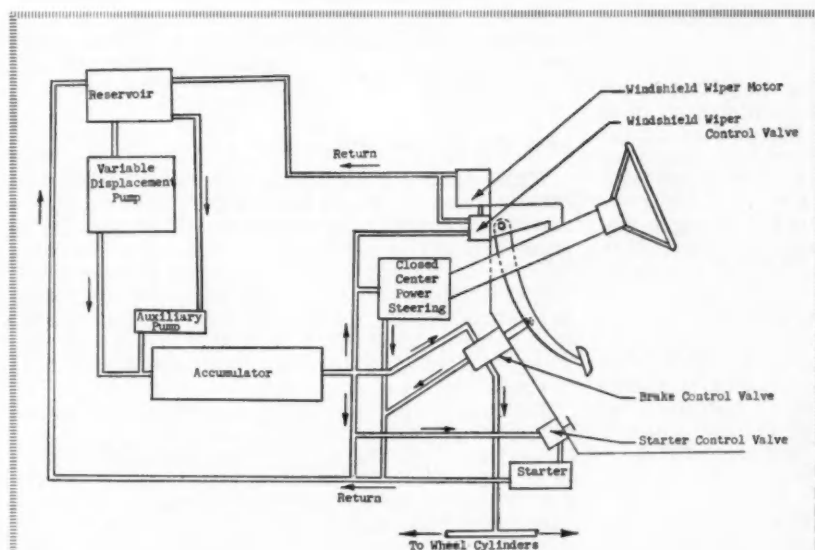


Fig. 3—A variable displacement pump permits the operation of a single high-pressure system. This system is necessary if any of the power units are operated for long intervals and also need a large flow of high pressure fluid. In such a case a fixed displacement pump overheats the fluid when the accessories are turned off.

(Tentative)

Table 1 — Central Hydraulic Power Fluids (Petroleum Base)

Viscosity	2000 c. s. max at -40 F (before shear) 47 SUS min at 210 F (after shear)
Shear Test	Not less than 20 hr running in a power steering pump (Eaton or equivalent).
Flash Point	225 F min.
Initial Boiling Point	400 F min.
Pour Point	-70 F or below.
Foaming	ASTM D-892-46T test, no foam at end of 4-minutes foaming period, 500 ml foam volume at end of 5-minute blowing.
Lubricity	Equal to Automatic Transmission Fluid Type "A" fluid in an Eaton or equivalent power steering pump.
Oxidation Stability	Equal or better than ATF Type "A" fluid when tested in a Powerglide or Mercomatic transmission at stabilized temperature of 275 F for 300 hr.
Corrosion Resistance	For power assist fluids made from petroleum base stocks ASTM D-665-54 turbine oil test will be used with a steel test strip.
Seal Compatibility	Same as present SAE Standard 70R1 including stroking test (70R1, paragraph D-12) and cup swell test (70R1, paragraph D-10) except that Buna N cups must be used wherever petroleum base stock is tested.
Water Tolerance	For hydraulic fluids made from petroleum base stocks no water tolerance is possible and provisions must be made in the hydraulic-mechanical system for the elimination of water.
Compatibility	All hydraulic fluids made from petroleum base stock must be mutually compatible. It is not intended, however, that they be compatible with fluids made from synthetic materials.

Coming?

Central Hydraulics for Passenger Cars . . . continued

do not reflect the faster driver reaction time possible when the driver is less fatigued and doesn't have to exert as much braking effort. The system can, of course, be designed to give the driver just as good or better "feel" of his brakes. The aircraft industry has already demonstrated this fact.

Promise of no vapor lock failure is another advantage. Brake failure due to vapor lock will be impossible because the hydraulic system will keep supplying fluid as long as the driver has his foot on the pedal. Thus, "spongy-feeling" brakes is the worst effect possible, even if the brake fluid does boil.

The same continuous supply of fluid under pressure makes possible the development of non-skid brakes, currently used by the aircraft industry. As long as the driver keeps his foot on the pedal, a skid-sensing device can control the supply of fluid so that the brakes ease off as soon as the wheels begin to lock up and skid.

Two other plus values of a central hydraulic system are economy and ease of driving. Economy comes from consolidation of duplicate equipment into a central system. Driver fatigue is lessened be-

cause a car fully power-equipped takes less effort. Power brakes contribute especially to this latter advantage. Today, the system which usually operates power brakes is restricted by the available power from the vacuum boost. With a positive-pressure hydraulic system, braking is possible with less foot pressure and, if desired, with practically no brake pedal travel. The driver will not have to lift his foot to switch from accelerator to brake pedal.

how the system works

Three elements form the heart of a central hydraulic system: the pump, an accumulator, and a reservoir. From them, power may be tapped to operate a simple system such as steering and brakes (Fig. 1) or a complete range of power equipment. The accumulator acts as the "battery" of the system by storing the energy produced by the pump until it is needed. This allows a smaller pump and also gives the driver braking power even when the car is not running.

The simple system illustrated in Fig. 1 brings out several problems and possible solutions of a hydraulic system. The dual element pump shown supplies both high- and low-pressure fluid because the requirements of the brakes and steering are different. The pump runs constantly at engine speed. If only a high-pressure section were used, the power steering unit would force the pump to supply a large volume of high-pressure fluid. Producing this pressure

(Tentative)

Table 2 — Central Hydraulic Power Fluid (Synthetic)

Viscosity	2000 c. s. max at -40 F (before shear) 47 SUS min at 210 F (after shear)
Shear Test	Not less than 20 hr running in a power steering pump (Eaton or equivalent).
Flash Point	180 F min.
Initial Boiling Point	400 F min.
Pour Point	-70 F or below.
Foaming	ASTM D-892-46T test, no foam at end of 4-minutes foaming period, 500 ml foam volume at end of 5-minute blowing.
Lubricity	Equal to Automatic Transmission Fluid Type "A" fluid in an Eaton or equivalent power steering pump.
Oxidation Stability	Equal or better than ATF Type "A" fluid when tested in Powerglide or Mercomatic transmission at stabilized temperature of 275 F for 300 hr.
Corrosion Resistance	For hydraulic fluids made from all synthetic materials, the present test specified in 70R1 will be used.
Seal Compatibility	Same as present SAE Standard 70R1 including stroking test (70R1, paragraph D-12) and cup swell test (70R1, paragraph D-10).
Water Tolerance	For hydraulic fluids made from synthetic materials the present test specified in 70R1 will be used.
Compatibility	All power assist fluids made from synthetic materials must be mutually compatible. It is not intended, however, that they be compatible with fluids made from petroleum base stock.

and flow when the power steering unit didn't need it would overheat the fluid. On the other hand, the brakes need a small amount of high-pressure fluid which can be supplied by the dual element pump and stored in the accumulator without undue fluid temperature rise.

The accumulator also serves important safety purposes. It provides many safe stops should there be

a pump failure . . . and it makes possible the isolation of the brake system from malfunction in any other part of the hydraulic system. In this way, the brake system is similar to the present manual system and improves on the present vacuum system. The vacuum system takes extra foot pressure if power fails.

A more complete system is shown in Fig. 2. The

THIS ARTICLE is based on the work of two SAE technical committees. The groups actively working on a report on central hydraulic fluids for passenger cars are:

Subcommittee H — Power Assist Fluids of SAE Fuels & Lubricants Technical Committee.

C. J. Livingstone, Chm., Gulf Oil Corp.
M. D. Gjerde, Standard Oil Co., (Ind.)
W. S. James, Private Consultant
D. F. Miller, Chrysler Corp.
L. L. Withrow, General Motors Corp.
E. Koenig, Texas Co.
H. Kemmerer, Shell Oil Co.
L. Raymond, Socony Mobil Co.
A. E. Cleveland, Ford Motor Co.

Central Hydraulic Power Fluid Subcommittee of the SAE Non-Metallic Materials Committee.

Thomas H. Risk, Chm., Ford Motor Co.
C. M. Heinen, Chm., F & L Technical Committee, Chrysler Corp.
C. J. Livingstone, Chm., Subcommittee H, Gulf Oil Corp.
F. J. Markey, Chm., Hydraulic Brake Fluids Subcommittee, Moraine Products Division, GMC
V. T. Cortesi, B. F. Goodrich Co.
S. I. Mac Duff, Bendix Aviation Corp.
C. C. Raymond, Jr., Eaton Mfg. Co.
L. L. Withrow, General Motors Corp.

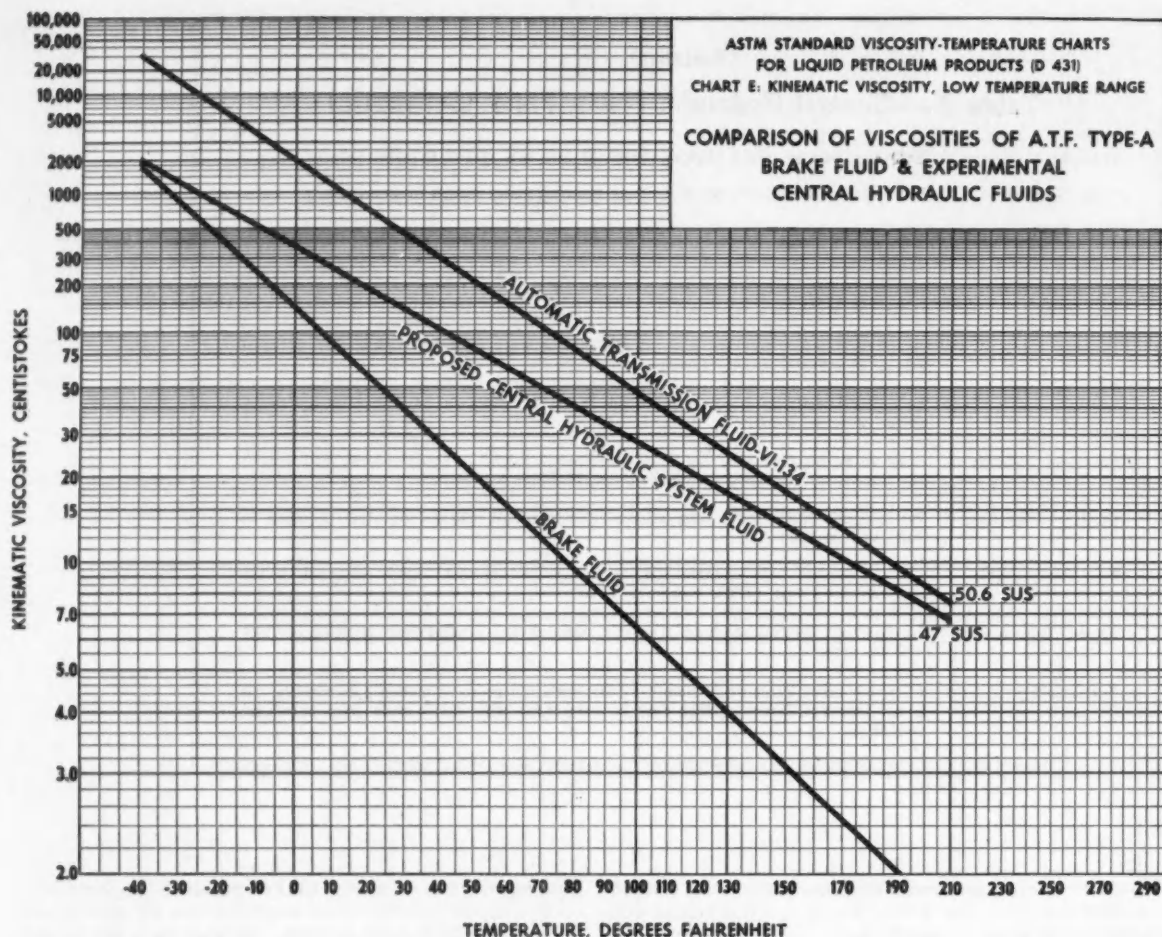


Fig. 4—Fluids for central hydraulic systems must have the low temperature viscosity of a brake fluid and the high temperature viscosity of a power steering fluid. The proposed central hydraulic system fluid actually has a higher viscosity at 210 F than the Automatic Transmission Fluid—Type "A" commonly used for power steering units. This is because its 47 SUS value is after shear tests while the 50.6 SUS figure is for a power steering fluid without shear tests. If the ATF viscosity were measured after shearing it is expected that the SUS value would be less than 47.

Coming?

Central Hydraulics for Passenger Cars . . . continued

hydraulic power starter needs a means for recharging if the car doesn't start by the time the accumulator runs down. This accounts for the auxiliary pump in the circuit shown. This pump could be driven by hand, by a mechanical linkage from a repair truck, or by an electric motor (battery or house voltage). Optional drive features in the pump would improve the flexibility of starting a stalled car.

The variable displacement pump used in the Fig.

3 system eliminates the need for a low-pressure fluid supply to the power steering unit and permits use of a closed center steering unit. This pump would supply fluid only when needed by one of the accessories or the accumulator. Thus, the fluid overheating problem faced with the fixed displacement pump shown in Figs. 1 and 2 is eliminated. Although not shown in the illustration, all the additional power accessories could be added to this system.

The variable displacement pump is a necessity if high-power, long-time accessories are to be operated, although it is inherently more expensive. Such accessories would overload the accumulator or the high-pressure element in a dual pump. If a high-volume, high-pressure, constant-displacement pump is used to satisfy these accessories . . . then the fluid will overheat when the accessories are not in use. Some examples of such accessories are

windshield wipers, air-conditioning, and suspension systems.

two fluids work in central hydraulic systems

A petroleum-based and a synthetic fluid have already been developed experimentally, each of which will meet the performance requirements of a central hydraulic system. The characteristics of these fluids are a composite of those of present hydraulic brake fluids and Automatic Transmission Fluid-Type "A".

The synthetic fluid can be used in the present brake systems and work as well or better than the performance called for by the SAE Standards 70R1 or 70R3. The petroleum base fluid will perform equally as well, but requires that Buna N brake cups be used. (This is because petroleum fluids cause natural rubber cups to swell.)

Use of a petroleum-based fluid will not cause confusion in the field, however, as the fill point will not resemble the opening of a master brake cylinder any more than do the present openings for crankcase oil, automatic transmission fluid, or power steering fluid. If a mechanic goes looking for a master cylinder to fill with brake fluid, he just won't find it. The fluid used for central hydraulic systems will undoubtedly be called anything but "brake fluid."

The performance requirements being considered for the two types of central hydraulic fluids are shown in Tables 1 and 2. These tables were developed by Subcommittee H—Power Assist Fluids of the SAE Fuels and Lubricants Technical Committee and coordinated by the Central Hydraulic Power Fluids Subcommittee of the SAE Non-Metallic Materials Committee. A final draft has not been approved.

Comparing the tables with the existing brake fluid standards shows that the boiling point is 25 F over the 70R3 Standard and 100 F over the 70R1 Standard. Also, the minimum flash point in Table 1 is 225 F and in Table 2 is 180 F. Presently, 70R1 calls for 145 F and 70R3 for 180 F.

The lubricating qualities of the central hydraulic fluid must far exceed the stroking tests called out in 70R. This is because the hydraulic pump works much harder than the brake cups in the brake cylinders.

The viscosity of the new fluids has bridged the gap between the existing brake and power steering fluids. This is shown in Fig. 4. The 2000 c.s. is comparable to the present 1800-c.s. requirement in 70R and the high-temperature viscosity far exceeds what is asked for in 70R.

Shear, oxidation, and lubricity tests are rapidly being put into standard form for incorporation in the coming report or for referencing as a separate report.

It is expected that the report on central hydraulic fluids will be considered as a recommended practice. Field test work indicates that it is probably too severe and may be "loosened" as more experience is gained. When sufficient service experience is accumulated and the report reviewed in light of later information, it may then qualify as a standard under SAE procedures. In the meantime, a conservative approach is being taken to insure safety.

Ceramics and Graphites

... Tested for hot-spot areas.

Based on paper by **J. M. Nowak** Bell Aircraft Corp.

BELL Aircraft has run a number of tests to determine the merits of:

1. Ceramic and graphite materials for hot spot areas.
2. Refractory inorganic materials as thermal insulants.

The refractories were being considered for the wing leading edges and the nose of a proposed hypersonic aircraft. The insulants were for application between the outer skins and the interior structure. Here are the results of these tests.

Refractory Materials for Hot Spot Areas

- Of the carbide materials tested the best oxidation resistance at 2800 F was exhibited by a refractory body consisting of 90% silicon carbide and 10% boron carbide (SiC-B₄C).

- At about 3700 F a standard dense silicon carbide body showed little deterioration after 10 min exposure in an oxy-acetylene furnace. Specimens subjected to 85 min exposure at these temperatures deteriorated quite badly resulting in loss of about 25% of the original volume of the specimen.

- An attempt to obtain by the addition of aluminum a commercially producible silicone carbide possessing a modulus of rupture approaching that of a hot pressed laboratory body was not successful. The strength of the aluminum modified body was less than that of the commercially available dense SiC.

- Graphite coated with SiC shows promise for applications at temperatures of at least 2800 F and possibly 3700 F for short periods. Coated graphite has a substantial weight advantage over SiC. The density of graphite is about 1.8 g per cc. The density of commercial varieties of silicon carbide vary from about 2.8 to 3.1 g per cc.

- Dense silicon carbide bodies had considerably higher modulus of rupture strength than silicon carbide—boron carbide bodies and zirconia bodies.

Thermal Insulants

- It appears that an alumina-silica fibrous insulant having a nominal density of 3 lb per cu ft shows the most promise as an insulant.

- The use of protective seals to prevent water absorption by fibrous insulants may be necessary.

To Order Paper No. 56S...

on which this article is based, see p. 6.

Hot Tunnel Facility . . .

Based on paper by

C. V. Hawk and J. W. Godfrey

Harrison Radiator Division, General Motors Corp.

DESIGN engineers now have a better tool to measure development of cooling systems. Field tests have confirmed that laboratory tests reproduce with accuracy the effects of cooling airflow, radiant heat loads, and relative humidity.

The hot tunnel test facility used by Harrison for indoor climatic testing is shown in Fig. 1. It has two parallel ducts communicating at each end. In the lower duct at the far left are six fans which discharge air through a rectangular duct to the front of the car. The end of the discharge duct telescopes to accommodate different wheelbases. At the far right of the tunnel are electrically operated doors and turning vanes for recirculating all of the air, or discharging a part and replenishing with an equal amount of fresh air.

The six fans — three counter-rotating sets of two each — are 10 ft in diameter. Each pair is controlled by a variable speed 100-hp motor. These motors, together with the damper doors in the upper duct, make it possible to get air velocities of 5 to 110 mph at the front of the car. Steam heating coils in the upper duct permit control of tunnel air temperatures from atmospheric up to 125 F.

Character of Tests

Standard hot tunnel engine cooling test procedures cover heat rejection, standard cooling (wide open throttle), grade cooling (7.2%, formerly 6%), road load, and idle run from 70 mph road load.

To determine how closely hot tunnel tests correlated with road tests, the cars were transported to Phoenix, Ariz., for road test at the GM Desert Proving Ground. As far as possible, these tests were conducted under conditions prevailing in the hot tunnel. Figs. 2 through 4 example the degree of correlation obtained.

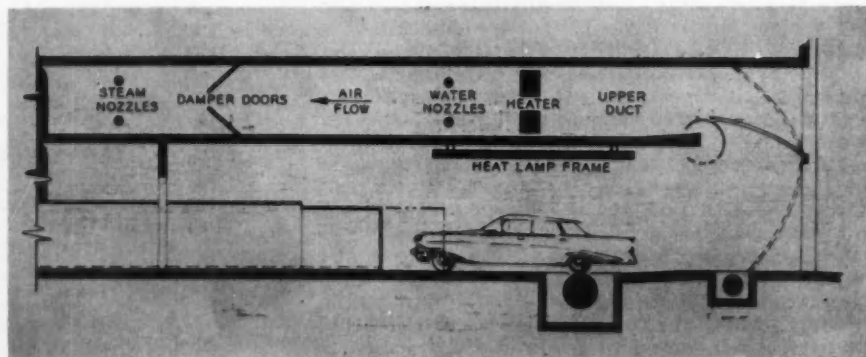
For performance evaluation of automotive air conditioning at high ambient conditions, three types of tests were used. These were: stabilized performance across the speed range, soak and cool-down, and comfort evaluation. Ambient conditions of 100 F dry bulb temperature and 40% relative humidity, with a simulated sun load, have been selected for the design condition.

After hot tunnel testing, the test car and escort car were driven to the vicinity of Vera Cruz, Mexico, during early February, where a road test was made. Fig. 5 shows the correlation obtained in the soak and cool-down test.

To Order Paper No. 22U . . .

. . . on which this article is based, turn to page 6.

Fig. 1 — Cut-away sketch of Harrison hot tunnel facility for year-round indoor climatic testing of engine cooling and air conditioning systems.



provides all-season climatic testing.

Results correlate well with road tests.

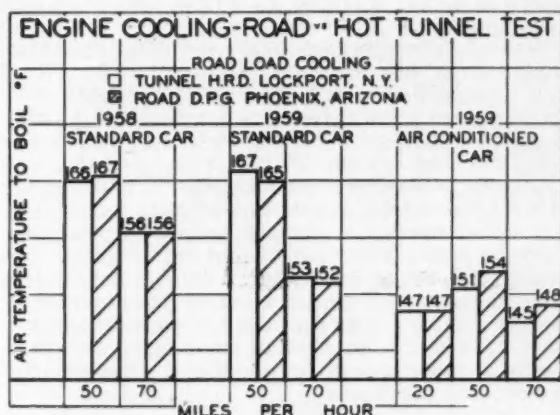


Fig. 2—Road load air-to-boil temperatures obtained on three cars in road and hot tunnel tests. Maximum variation in correlation is only 3 deg.

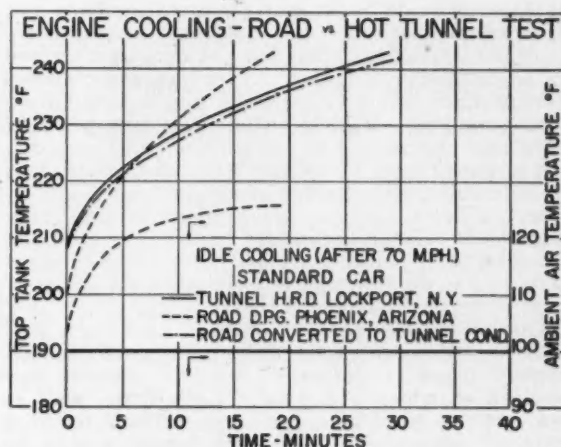


Fig. 4—Comparison of idle cooling tests. Hot tunnel ambients were maintained at 90 and 100 F, whereas proving ground temperatures at grille increased as much as 23 deg (F) during idle period.

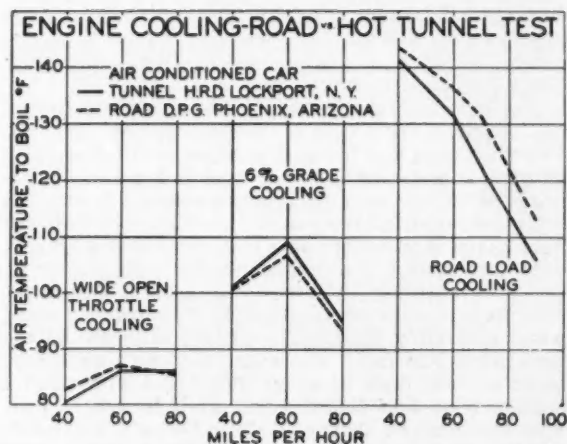


Fig. 3—Comparison of tests made with an air conditioned car, at wide open throttle, 6% grade, and road load. Correlation is considered to be within acceptable limits.

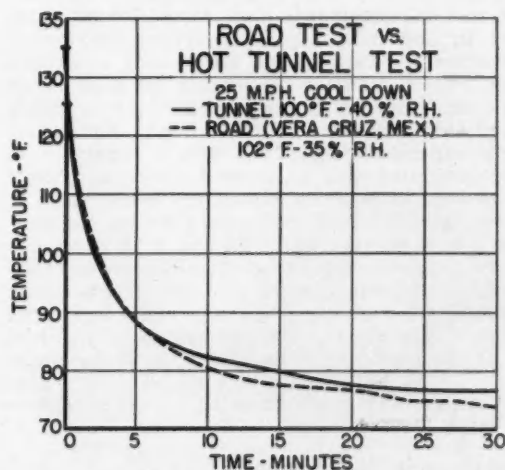


Fig. 5—Soak and cool-down tests correlate well. The two cars under test had been run several thousand miles between hot tunnel tests and road tests.

Evolution of . . .

Hillman Unitized Construction

Based on paper by

A. C. Booth and B. B. Winter

Rootes Group, England

HILLMAN'S aim in switching to a unitary body and chassis construction was to decrease manufacturing costs, and at the same time get a stiffer structure to accommodate a higher output engine for better performance without suffering a weight penalty.

The marriage of body and chassis took place in 1939 and, although it involved higher tooling costs, these were offset by greater output, simplification of assembly, reduction in number of parts and in body mounting labor. Furthermore, rectification costs were slashed because of the sealing in of the finished body before final assembly. The integral structure actually weighed 75 lb less than the two-part structure it replaced.

One argument against unitized construction—that it would restrict the outlet for alternative body types—proved unfounded. A basic structure was evolved on which a variety of body types, such as convertibles, hard tops, and vans, can be fabricated without prejudice to the much larger volume of sedan models. The point is to know the requirements from the outset.

First unitized design

Figs. 1 and 2 illustrate the first attempt at integration of body and understructure. The approach was to concentrate most of the longitudinal support in the fabricated box-section side-members, formed by welding the lower body sills to a channel section member supporting the floor. The propeller shaft tunnel, rear seat pan, and heel-board provided the stiffness across the floor. Having no accident experience with this type of assembly, it was deemed advisable to leave fenders and their inner panels as separate bolted-on items, easy to replace. For necessary front-end rigidity, the projecting side-members were formed into deep triangulated structures merging with the front bulkhead. Large stampings were used wherever possible. For example, a complete body side panel was made as a single stamping and flash-welded to the roof panel at the peak of the cantrail and to the bulkhead.

This design was retained, with minor modifications, until 1949.

Second phase in development

Primary objectives for the new design brought out in 1949 were: advances in styling, a more aerody-

namic shape with lower roof line, improved passenger space, and provision for easy assembly of the independent front suspension unit. To meet these objectives, the body sides were taken out to the full width of the car, aligning them flush with front and rear fenders.

The new underframe is shown in Fig. 3. The main longitudinal side-members ran the full length of the understructure independent of the body sills, to give extra support to the wider floor and provide a direct means of mounting the front suspension cross-member. With shallower sections for the underframe members and body sills, it was possible to lower the floor and roof line without compromising either interior headroom or ground clearance.

Front fender inner panels and rear fenders were welded into the basic structure. Later, front fenders became part of the welded assembly, thus increasing overall rigidity. Body side and roof panel design was revised so that spot welding could replace the expense of rubbing down and buffing the flash welded joints used previously.

Current integral design

A completely redesigned and retooled unitized structure was introduced in 1956. Again, definite objectives were sought, such as more advanced styling with lower silhouette, better weight distribution, wider seating, simplified rear entry. The wheelbase was lengthened 3 in., engine and transmission were moved further forward (to seat passengers well within the wheelbase), overall height was reduced 1½ in. and baggage space was increased by almost one-third.

The under-structure was altered, mainly to get the required reduction in vehicle height (Fig. 4). The floor level was lowered relative to the body sills to give a step-down effect, this being more pronounced at the rear to insure adequate headroom with the rapid fallaway in the roof line. The lower floor made it impracticable to carry the side-members throughout the length of the understructure and still maintain sufficient rear ground clearance. Therefore, they were arranged as forward and rearward extending subframes from transverse members below the front and rear seats with an unobstructed rear floor between them, and with deeper section body sills closed along their length to provide the desired stiffness. The forward extension of the subframe merged with the bulkhead and built-in fenders. The torsional rigidity is shown in Fig. 5.

In this design the body side panels are fabricated

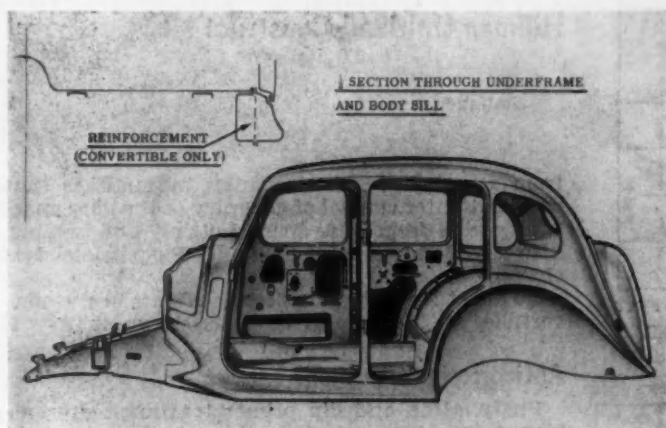


Fig. 1
Hillman unitary body and underframe assembly of 20 years ago. This original design was retained for 10 years.

Fig. 2
Underframe assembly of Hillman's first integrally designed structure. Longitudinal support was concentrated in box-section side-members formed by welding lower body sills to a channel section member supporting floor.

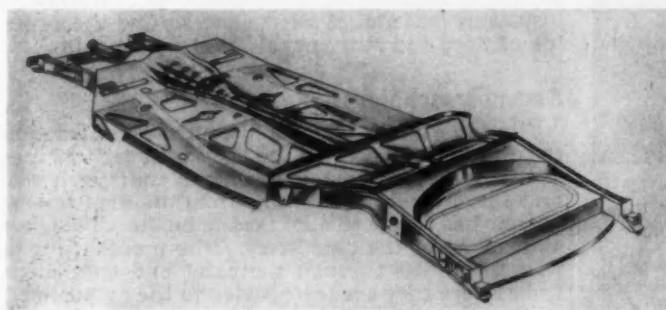
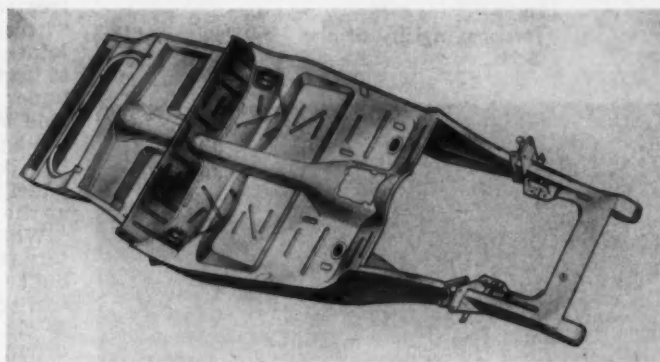
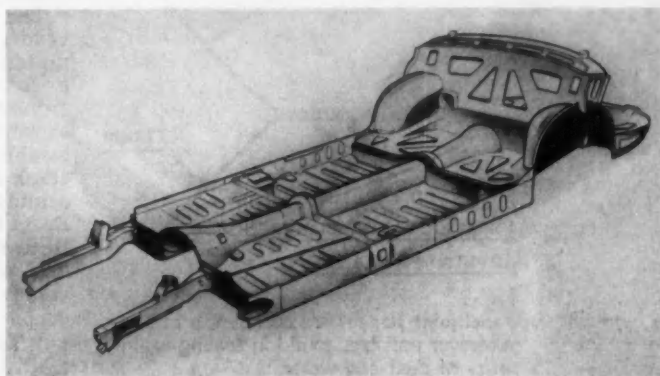
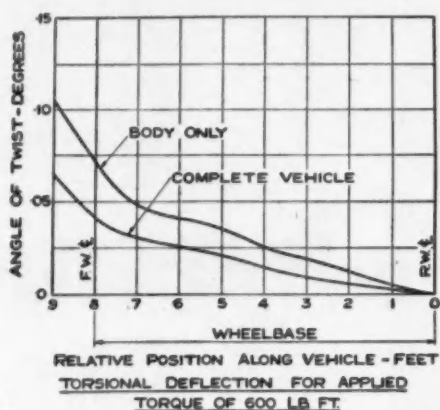


Fig. 3
Redesigned underframe assembly introduced in 1949 made possible lowering floor and roof line without compromising headroom or ground clearance.

Fig. 4
Current Hillman understructure lowers floor relative to body sills and makes for lower, roomier car.





TORSIONAL RIGIDITY OVER WHEELBASE LB FT/DEG		
SEDAN	BODY ONLY	10000
	COMPLETE VEHICLE	14000

Fig. 5
Torsional rigidity of the 1959 Hillman Minx sedan.

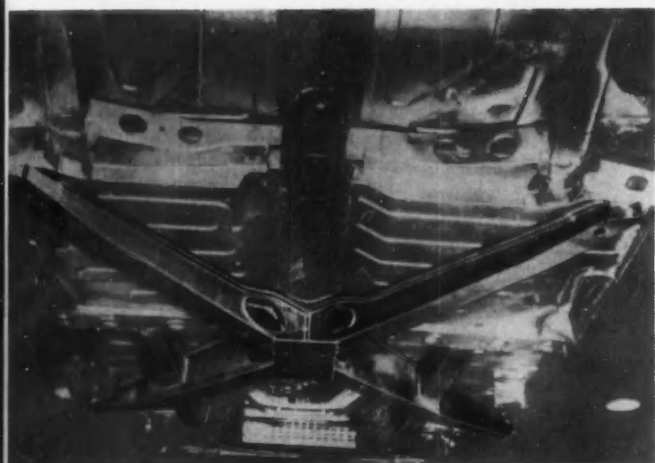


Fig. 6
Loss of torsional stiffness in convertible model, due to absence of roof panel, is partially offset by use of X-brace on understructure.

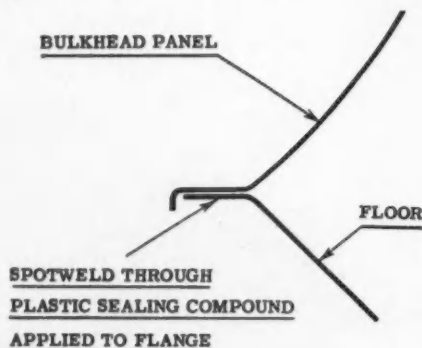


Fig. 7
Panel joint flanges are curled over at edge, wherever possible, to aid in sealing against entry of dust and water.

Hillman Unitized Construction

... continued

from a series of smaller panels by methods that provide tighter control of accuracy of the door apertures, with improved door shutting and sealing. Also provided is greater flexibility for possible style changes.

To offset the loss of torsional stiffness in the convertible, an X-brace is used, as shown in Fig. 6.

Anticorrosion treatment

Phosphating and dip primer treatment are employed and an approved plastic sealer is used wherever necessary. All mating flanges of panels are treated with zinc dust primer before welding, and with sealing material. Every effort is made to avoid joints exposed to the entry of dust and water, and to insure that those which are exposed (particularly under the floor and wheelarches) are sealed by suitable welding or plastic means during fabrication of the bodyshell. A greater use of continuous welding has been introduced and, wherever possible, the panel joint flanges have been designed to curl over at the ends (Fig. 7).

While hand-made prototypes had been satisfactory from the noise standpoint, the first production-built cars were disappointing. Compared with earlier orthodox construction they were less prone to shake and rattles, but more affected by panel drumming and resonance at critical speeds. This state of affairs was corrected by application of approved panel damping materials, large quantities of insulating material at selected areas, and the swaging of floor and other panels at strategic points.

Assembly techniques

The opportunity afforded by unitized construction to paint, trim, and equip the body with such fittings as the steering column, instruments, controls, hand-brake lever, and pedals, away from the final assembly line has produced a marked reduction in damage and soiling of the upholstery. The procedure is to pass the bodies through the paint and trim shops from where they are transported to the "premount" track, where the aforementioned hardware is installed.

The completed bodies progress on overhead conveyors, at a height convenient for operators to work underneath, and meet the chassis units moving on a converging lower track. Engine, transmission, front suspension unit, propeller shaft, rear axle, and suspension are all bolted together to form single assemblies on the lower moving track. The lower track is angled upward so that each unit chassis assembly is raised to meet a fully equipped body. From there the entire assembly travels on the overhead moving track for bolting of the chassis units and subsidiary operations until the finished car comes down to ground level.

To Order Paper No. 33R...

... on which this article is based, turn to page 6.

Air Force program evaluates
the machining characteristics of

AISI 4340 Low Alloy Steel

Based on paper by

P. R. Arzt, J. V. Gould, and J. Maranchik, Jr.

Metcut Research Associates, Inc.

APPPLICATION of ultra-high-strength thermal-resistant alloys for airframe, missile, and engine components has been steadily increasing in the past few years. The speed of many of the present-day aircraft imposes thermal conditions on the airframe and powerplant which necessitates the use of ultra-high-strength thermal resistant alloys for critical components. Future aircraft designed to operate at even higher speeds with increased aerodynamic friction heating and higher engine temperatures will require an even greater use of such alloys in airframe, missile, and engine construction.

Many of these alloys are new to the industry and meager machining information is available for use in setting up production machining operations. For the more familiar materials such as the martensitic low-alloy steels, hot-work die steels, and martensitic stainless steel there is a lack of data for machining in the high hardness ranges. Hence, a trial and error method must be used in the production operations which involves considerable time and expense.

The loss of time due to development of the production machining process can seriously disrupt planned schedules for new airframes and engines. Because schedules must be adhered to, production manufacturing departments are limited as far as process development is concerned. As a result, manufacturing of the components is done by any available method. The manufacturing process, in many cases, loses the identity of a production operation and becomes a tool room operation. The need for machinability information to be used as an aid in setting up production processing on the high-strength thermal-resistant alloys becomes evident.

This article presents results of machinability studies made to date on AISI 4340 martensitic low-alloy steel.

Turning Tests

Turning proved to be the least difficult of the various types of machining operations studied for the

THE AIR FORCE has set up a program to evaluate the machining characteristics of the more commonly used high-strength thermal-resistant materials. The work is being performed by Metcut Research Associates, Inc. under contract to Wright Aeronautical Division of the Curtiss-Wright Corp.

Four materials are being tested:

Alloy Group	Representative Alloy Selected for Machinability Studies
Martensitic low alloy steels	AISI 4340 quenched and tempered to 50-55 Rockwell C.
Hot work die steels	Vasco Jet 1000 quenched and tempered to 50-55 Rockwell C.
Precipitation hardening stainless steels	AM-350 solution treated and aged.
Austenitic stainless steels	A-286 solution treated and aged.

This article discusses the test results, to date, on AISI 4340. The other materials will be discussed in SAE Journal as follows:

Vasco Jet 1000 June
AM-350 July
A-286 August

Fig. 1 — Turning 4340 steel quenched and tempered to 514 Bhn (52 Rockwell C). Tool: carbide (see graph); side rake: 5 deg neg.; back rake: 5 deg neg.; nose radius: 0.032 in.; side cutting edge angle: 15 deg; end cutting edge angle: 15 deg; relief: 5 deg. Mechanical chip breaker. Feed: 0.009 in. per rev.; depth of cut: 0.100 in.; cutting fluid: none; wearland: 0.015 in.

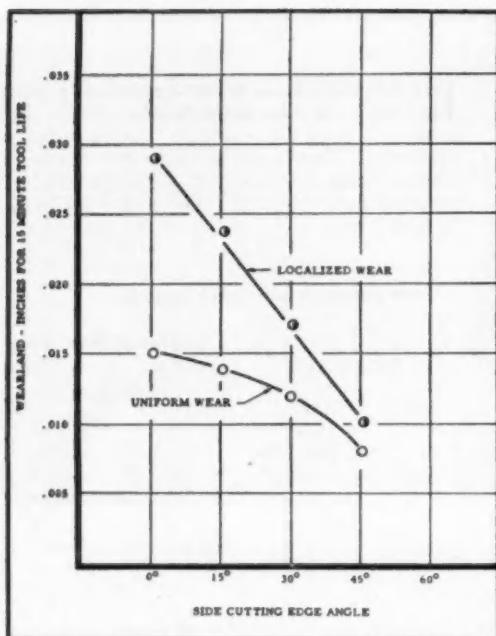


Fig. 3 — Turning 4340 steel quenched and tempered to 514 Bhn (52 Rockwell C); effect of feed. Tool: C-8 carbide; side rake: 5 deg neg.; back rake: 5 deg neg.; nose radius: 0.032 in.; side cutting edge angle: 15 deg; end cutting edge angle: 15 deg; relief: 5 deg. Mechanical chip breaker. Feed: see graph; depth of cut: 0.100 in.; cutting fluid: none; wearland: 0.015 in.

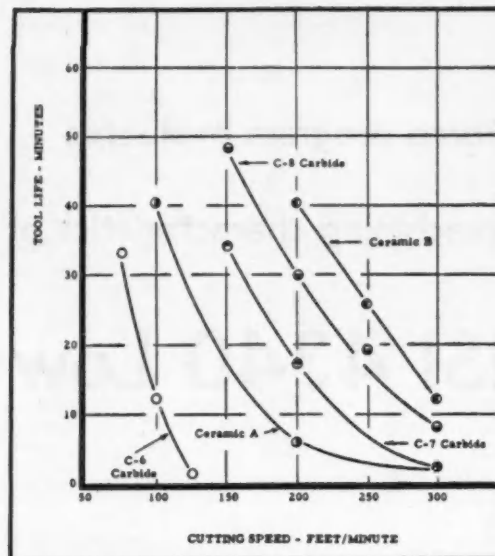
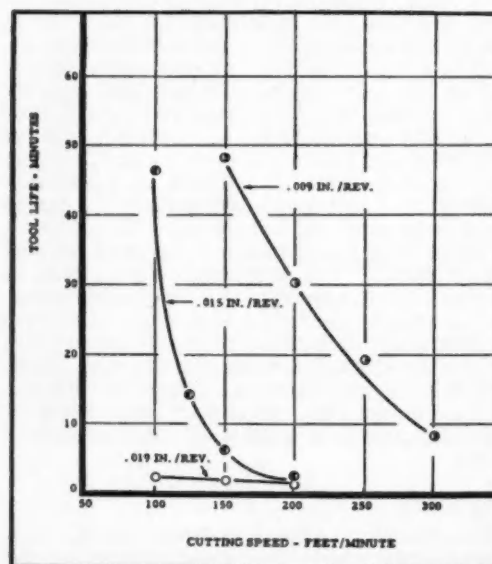


Fig. 2 — Turning 4340 steel quenched and tempered to 514 Bhn (52 Rockwell C); effect of side cutting edge angle on tool wear. Tool: C-7 carbide; side rake: 5 deg neg.; back rake: 5 deg neg.; nose radius: 0.032 in.; side cutting edge angle: 15 deg; end cutting edge angle: 15 deg; relief: 5 deg. Mechanical chip breaker. Feed: 0.009 in. per rev.; cutting speed: 150 fpm; depth: 0.100 in.; cutting fluid: none.



AISI 4340 Low Alloy Steel

... continued

ultra-high-strength thermal-resistant alloys. It was possible to obtain reasonable tool life in turning without resorting to unusual types of tools, tool geometries, or techniques. Good tool life results can be obtained by adhering to the following general recommendations:

1. Use a rigid machine and strong, solid tools and fixtures.
2. Use the proper type of carbide. For a given type of carbide, select the hardest grade that will perform without chipping.
3. Use cutting speeds, feeds, and tool geometries selected from turning data obtained under controlled cutting conditions.

Tool life results for AISI 4340, quenched and tempered to 52 Rockwell C are shown in Figs. 1-3.

Milling Tests

The problem which stands out above all others is the milling of the high-strength thermal-resistant alloys in airframe and missile components. This problem has been brought about by the change from aluminum to high-strength-steel airframe components. Following are the important types of milling operations and typical cuts being made for each type of operation.

Operation	Dimensions of Cut
Face milling	0.060 in. to 0.250 in. depth 1 in. to 5 in. width
End milling	Pockets 4 in. x 4 in. to 8 in. x 8 in. area ¼ in. to 3 in. depth Pockets in thin sheet 8 in. x 10 in. area 0.025 in. to 0.050 in. depth Milling side of rib 0.020 in. to 0.060 in. depth 2 in. to 3 in. height of rib Profiling 0.060 in. to 0.300 in. depth ½ in. to 2 in. width
Side milling	Spars ½ in. to 2 in. width ⅛ in. to ½ in. depth Up to 25 ft length
Slot milling	Hinges 3/16 in. to ½ in. width ½ in. to 1 in. depth ½ in. to 1 in. length Clevises ¼ in. to 1 in. width 1 in. to 2 in. depth 1 in. to 3 in. length Wing Spar 1 in. to 2 in. width 1 in. to 1½ in. depth Up to 15 ft length

Emphasis will be given here to information and data obtained in milling AISI 4340 in the high hardness ranges.

Face Milling Tests

In face milling tests on AISI 4340 quenched and tempered to 52 R_c, a study was made to determine the optimum cutter geometry and tool angles. To establish the optimum tool angles, a series of tests was run in which the angle of inclination was kept constant while the resultant rake was varied. Another series of tests was made in which the resultant rake was held constant and the angle of inclination was varied.

From these tests it was found that a resultant rake of -10 deg and an angle of inclination of 10 deg produced by an axial rake of 0 deg and a negative 15 deg radial rake with a 45 deg corner angle provided the best tool life when face milling the hardened 4340 steel.

The tool life in face milling is given in inches of work travel. The tool life end point was arbitrarily taken as 0.016 in. uniform on the peripheral flank of the cutter tooth, or localized breakdown, whichever occurred first. A 2 in. width of cut and 0.100 in. depth of cut was kept constant for all face milling tests.

With a 5-tooth face mill tipped with a C-6 grade carbide, a cutting speed of 150 fpm, and a feed of 0.005 in. per tooth, it was possible to mill 330 in. of material (see Fig. 4). At a cutting speed of 190 fpm and a feed of 0.005 in. per rev., tool life for a 10-tooth

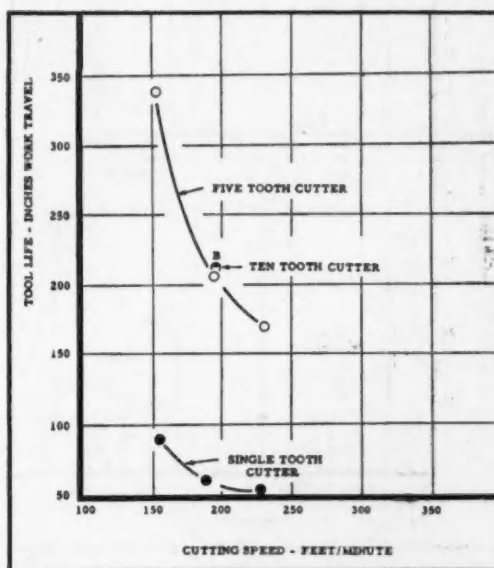


Fig. 4—Face milling 4340 steel quenched and tempered to 514 Bhn (52 Rockwell C). Tool: 5 in. diameter face mill with C-6 carbide; axial rake: 0 deg; radial rake: 15 deg neg.; corner angle: 45 deg; clearance: 8 deg; true rake: 10 deg neg.; angle of inclination: 10 deg; end cutting edge angle: 5 deg; feed per tooth: 0.005 in.; depth: 0.100 in.; width: 2.25 in.; cutting fluid: none; wearland: 0.015 in.; end of test determined by 0.030 in. localized breakdown.

AISI 4340 Low Alloy Steel

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cutter was essentially the same as for a 5-tooth cutter. Localized breakdown of the cutter teeth occurred when using the 10-tooth face milling cutter.

Face milling tests made to study the effect of feed rate indicated that a feed of 0.005 in. per tooth was the best feed rate to use in face milling 52 R_c 4340 steel. The tool life obtained at 0.005 in. per tooth feed was more than twice that obtained when face milling with feeds of 0.0025 in. per tooth and 0.0075 in. per tooth.

Face milling tests on 4340 quenched and tempered to 52 R_c indicated that cutter run-out becomes a very critical factor in tool life. Using a 5-tooth face mill feeding at 0.005 in. per tooth, with a total cutter run-out of 0.003 in., reduced tool life by about 25% and localized wear developed rather than uniform wear on the cutter. With a total run-out of 0.005 in., tool life was reduced by some 65% and severe localized wear caused cutter breakdown.

Side Milling

Side milling tests were made, using a 7 in. diameter inserted tooth face mill, on AISI 4340 quenched

and tempered to 52 R_c. A tool material and tool geometry evaluation using a single tooth in the cutter showed best results could be obtained when up-milling, using a C-6 carbide grade cutter with -5 deg axial rake and -10 deg radial rake. As shown in Fig. 5, tool life was 72 in. work travel when milling at a cutting speed of 145 fpm and a feed of 0.0075 in. per tooth.

When down-milling with a C-6 grade carbide, severe tooth chippage was encountered and tool life was only 20 in. work travel. Down-milling was found to be best when using a C-2 grade of carbide; however, maximum tool life was only 50% of that obtained from up-milling with a C-6 carbide grade.

The tool life curve, Fig. 6, shows that 380 in. were cut with 6 teeth in the cutter at a cutting speed of 145 fpm and a feed of 0.0075 in. per tooth. When the feed was increased to 0.010 in. per tooth, tool life decreased to 220 in. work travel.

End Milling

The end milling tests consisted of milling 1/4 in. deep slots using 3/4 in. diameter, high-speed end mills and 1 1/4 in. diameter carbide end mills. Tool life is given in inches of work travel for a tool-life end point of 0.016 in. uniform wear or localized breakdown, whichever occurred first.

Preliminary tests were made in end milling AISI

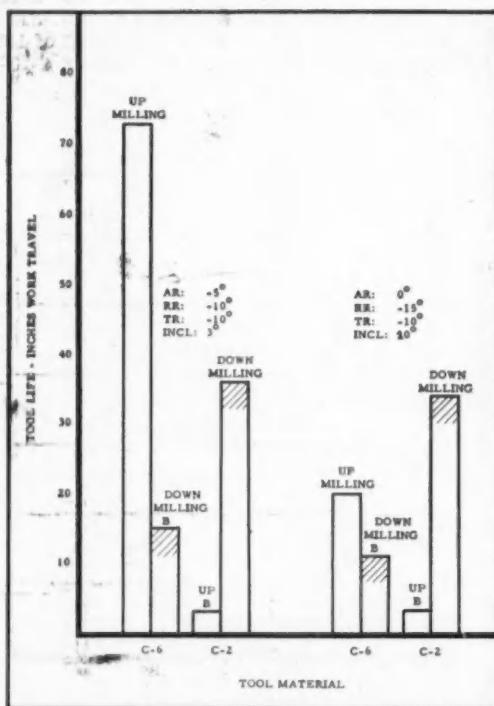


Fig. 5—Side milling 4340 steel quenched and tempered to 52 Rockwell C; effect of tool material and geometry—single tooth cutter. Tool: 7 in. diameter inserted tooth cutter; corner angle: 45 deg; end cutting edge angle: 5 deg; peripheral clearance: 8 deg; cutting speed: 145 fpm; feed per tooth: 0.0075 in.; depth: 0.100 in.; width: 1.750 in.; cutting fluid: none; wearland 0.015 in. End of test determined by localized breakdown.

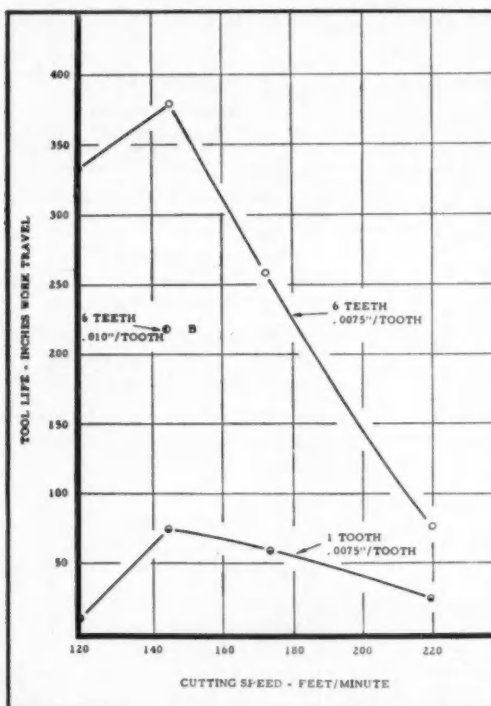


Fig. 6—Side milling 4340 steel quenched and tempered to 52 Rockwell C; multiple tooth cutter—up milling. Tool: 7 in. diameter inserted tooth cutter with C-6 carbide; axial rake: 5 deg neg.; radial rake: 10 deg neg.; corner angle: 45 deg; true rake: 10 deg neg.; angle of inclination: 3 deg neg.; end cutting edge angle: 5 deg; peripheral clearance: 8 deg; feed per tooth: see graph; depth: 0.100 in.; width: 1.750 in.; cutting fluid: none; wearland: 0.015 in. End of test determined by localized breakdown.

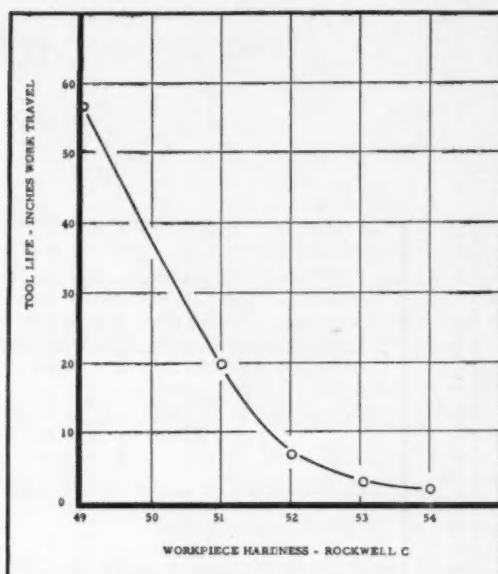


Fig. 8 — End milling 4340 steel; quenched and tempered to 470 Bhn (49 Rockwell C). Tool: HSS $\frac{3}{4}$ in. diameter 4-flute end mill; helix angle: 35 deg right-hand helix, right-hand cut; radial rake: 15 deg; corner angle: 45 deg, 0.060 in. wide; side clearance: 5 deg primary, 10 deg secondary; end clearance: 5 deg primary, 20 deg secondary; feed per tooth: 0.001 in.; depth: 0.250 in.; width: 0.750 in.; cutting fluid soluble oil (1:20); wearland: 0.016 in.

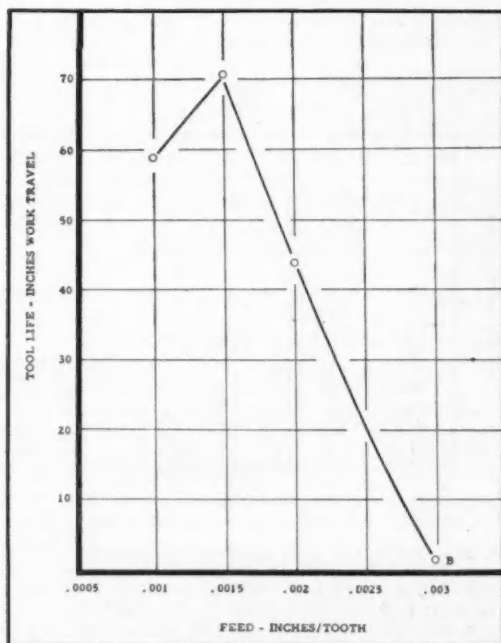


Fig. 7 — End milling 4340 steel — effect of workpiece hardness. Tool: T-15 HSS $\frac{3}{4}$ in. diameter 4-flute end mill; helix angle: 35 deg right-hand helix, right-hand cut; radial rake: 15 deg; corner angle: 45 deg, 0.060 in. wide; side clearance: 5 deg primary, 10 deg secondary; end clearance: 5 deg primary, 20 deg secondary; speed: 37 fpm; feed per tooth: 0.0005 in.; depth: 0.250 in.; width: 0.750 in.; cutting fluid: soluble oil (1:20); wearland: 0.016 in.

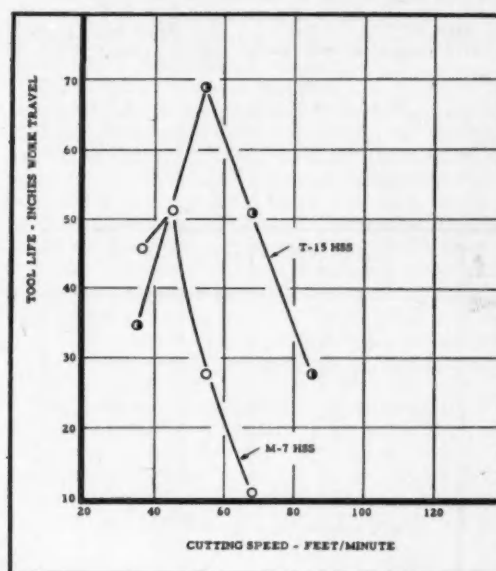


Fig. 9 — End milling 4340 steel quenched and tempered to 52 Rockwell C. Tool: $1\frac{1}{4}$ in. diameter 4-tooth end mill with C-2 carbide; axial rake: 5 deg neg.; radial rake: 0 deg; true rake: 0 deg; end cutting edge angle: 3 deg; corner angle: 45 deg, 0.030 in. wide; peripheral clearance: 15 deg; end clearance: 5 deg; cutting speed: 50 fpm; depth: 0.250 in.; width: 1.250 in.; cutting fluid: chemical emulsion (40:1) applied as mist through cutter; wearland: 0.015 in. End of test determined by localized breakdown.

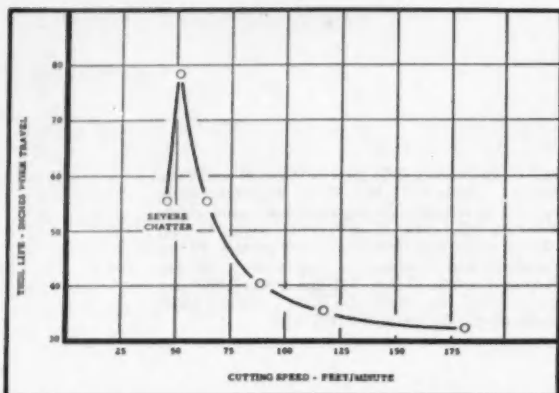


Fig. 10 — Carbide end milling 4340 steel quenched and tempered to 52 Rockwell C. Tool: 1/4 in. diameter heavy duty 4-tooth end mill with C-2 carbide; axial rake: 0 deg; radial rake: 0 deg; true rake: 0 deg; end cutting edge angle: 3 deg; corner angle: 45 deg; 0.030 in. wide; peripheral clearance: 15 deg; end clearance: 5 deg; feed per tooth: 0.0015 in.; depth 0.250 in.; width: 1.250 in.; cutting fluid: chemical emulsion (40:1) applied as mist through cutter; wearland: 0.015 in.

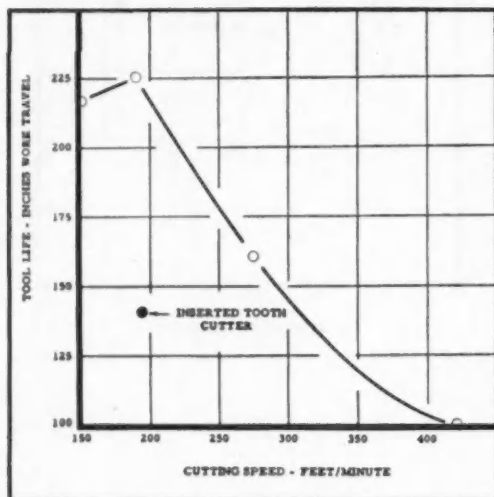


Fig. 11 — Slotting 4340 steel quenched and tempered to 52 Rockwell C; multiple tooth cutter—down milling. Tool: 6 in. diameter 6-tooth cutter with brazed-on C-2 carbide; axial rake: 5 deg bi-neg.; radial rake: 10 deg neg.; corner angle: 45 deg; 0.030 in. wide; true rake: 10 deg neg.; angle of inclination: 5 deg neg.; end cutting edge angle: 1 deg; peripheral clearance: 8 deg; feed per tooth: 0.005 in.; depth: 0.250 in.; width: 1 in.; cutting fluid: none; wearland: 0.015 in.

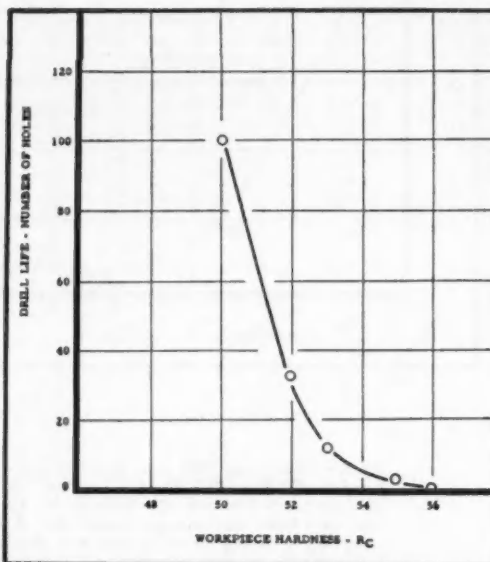


Fig. 12 — Drilling 4340 steel quenched and tempered; effect of workpiece hardness. Drill: T-15 HSS; diameter: 0.250 in.; length: 2.75 in.; clearance: 7 deg; point grind: crankshaft; cutting speed: 30 fpm; feed: 0.001 in. per rev.; depth of hole: 0.500 in.; cutting fluid: highly sulphurized oil diluted 1:1 with light machine oil; wearland: 0.015 in.

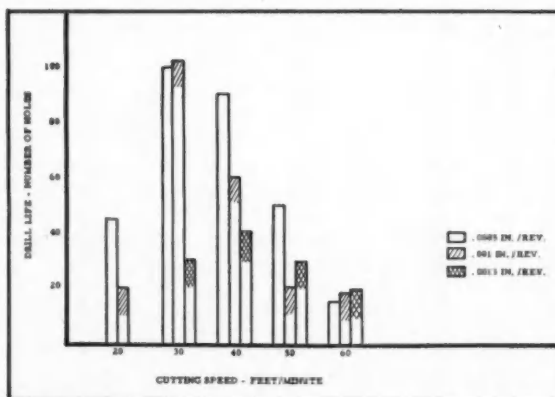


Fig. 13 — Drilling 4340 steel quenched and tempered to 482 Bhn (50 Rockwell C); effect of feed. Drill: T-15 HSS; diameter: 0.250 in.; length: 2.75 in.; point angle: 118 deg; clearance: 7 deg; point grind: crankshaft; feed: see graph; depth of hole: 0.500 in.; cutting fluid: highly sulphurized oil diluted 1:1 with light machine oil; wearland: 0.015 in.

AISI 4340 Low Alloy Steel

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4340 quenched and tempered to 49-54 R_c with high-speed steel cutters. These tests were designed to establish cutting speeds and feeds that would result in reasonable tool life. Very inconsistent tool life results were observed, despite careful control of cutter geometry and emphasis on rigidity of the setup. That hardness was a critical variable. A series of tests was then made to determine the effect of work. A systematic analysis of all of the data indicated piece hardness on tool life.

Fig. 7 shows the effect of workpiece hardness on tool life for 4340 steel at hardnesses of 49-54 R_c, using T-15 high-speed steel cutters, a feed of 0.0005 in. per tooth and a cutting speed of 37 fpm. Good tool life was obtained with a workpiece hardness of 49-50 R_c. However, tool life decreased rapidly as hardness increased from 49 to 52 R_c. For workpiece hardness above 52 R_c, the material was, for all practical purposes, unmachinable with the high-speed steel end mills used in the tests.

The tool life curves shown in Fig. 8 for end milling 49 R_c 4340 steel indicate the importance of selecting the correct cutting speed to attain maximum tool life. Using a feed of 0.001 in. per tooth and depth of cut of 1/4 in. tool life using a T-15 cutter increased rapidly with decreasing cutting speed between 85 fpm and 55 fpm, then decreased rapidly. For the M-7 cutter, tool life increased rapidly for decreasing cutting speeds between 70 fpm and 45 fpm, then decreased with decreasing cutting speeds.

Tests made to determine optimum feed rates indicated that feeds between 0.001 in. per tooth and 0.0015 in. per tooth must be used to attain a reasonable tool life in end milling 49 R_c 4340 steel using high-speed end mills.

The initial tests in carbide end milling of AISI 4340 quenched and tempered to 52 R_c were all made with standard 1 1/4 in. diameter, 4-tooth carbide-tipped end mills having 1 in. diameter shanks, 1 1/4 in. flute length, and overall length of 4 1/4 in. Considerable cutter deflection and resultant poor life were observed.

To increase rigidity, special end mills were designed and made with a shank diameter of 1 1/4 in., and the flute length cut down to 3/4 in. These end milling cutters were used in all subsequent tests.

An evaluation of carbides for end milling showed that a C-2 grade carbide provided better tool life than a C-6 carbide grade. In addition, wear on the carbide teeth was uniform and showed no evidence of chipping. With a C-6 steel cutting grade of carbide, tool life was about 1/6 of that obtained with a C-2 nonferrous grade carbide.

End milling of 52 R_c 4340 steel with carbide end mills requires the use of cutting fluid to attain maximum tool life.

Investigation of various methods of coolant application showed that by applying the cutting fluid as a mist through the cutter, an appreciable increase in tool life can be obtained. The coolant mist was

fed through a hollow draw bolt through the cutter to the tool work interface. The improvement in tool life is attributed partially to the better chip removal effected by the air pressure used to produce the mist.

The feed curve shown in Fig. 9 indicates that optimum feed was 0.0015 in. per tooth in carbide end milling of 52 R_c 4340 steel.

A tool life of 78 in. of work was obtained in carbide end milling of 52 R_c 4340 steel using a feed of 0.0015 in. per rev. and a cutting speed of 50 fpm (see Fig. 10).

Slotting Tests

Machining tests using a 6 in. diameter, 1 in. wide slotting cutter were made on AISI 4340 quenched and tempered to 52 R_c. The tests consisted of milling a slot 0.250 in. deep by 1 in. wide in the workpiece on a Cincinnati No. 6 high power horizontal mill. To obtain maximum rigidity of the setup, a 2 in. diameter arbor was used and the slotting cutter kept as close to the spindle nose as possible. Overhang of the overarm was kept at a minimum. Tool life when slotting was recorded as the inches of work travel before cutter breakdown took place.

The initial testing consisted of a carbide evaluation and rake angle evaluation to determine the best tool material and tool geometry for slotting the hardened alloys. The carbide evaluation showed that the nonferrous C-2 grades of carbide were much better for slot milling than the steel cutting C-6 grades of carbide. With a C-2 carbide, tool life was about four times higher than that obtained with a C-6 grade carbide. The C-2 carbide wore uniformly along the cutting edge, while the C-6 grade fractured and chipped badly. Tests with a C-3 grade of carbide provided a tool life about the same as that obtained with a C-2 grade, but severe chipping was evident on the teeth.

The rake angle evaluation indicated that a rake combination of bi-negative 5 deg axial rake and -10 deg radial rake produced the highest tool life. The face of the carbide tooth was ground to produce the bi-negative 5 deg axial rake on both corners of the tip. When looking at the carbide tip in a radial

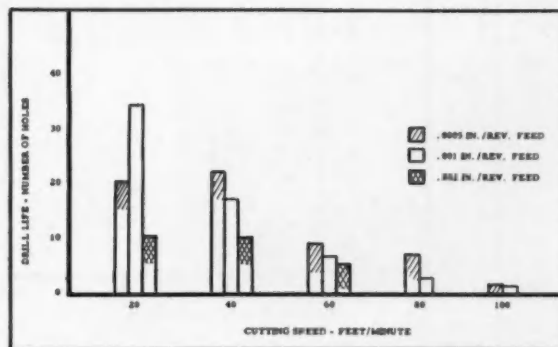


Fig. 14—Drilling 4340 steel quenched and tempered to 514 Bhn (52 Rockwell C); effect of feed. Drill: T-15 HSS; diameter: 0.250 in.; length: 2.75 in.; point angle: 118 deg; helix angle: 29 deg; point grind: crankshaft; clearance: 7 deg; depth of hole: 0.500 in.; cutting fluid: highly sulphurized oil diluted 1:1 with light machine oil; wearland: 0.015 in.

AISI 4340 Low Alloy Steel

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plane, the cutting edge face shows a wedge shape because of the -5 deg axial rake ground on both corners. Both corners were ground with a 0.030 in. wide 45 deg corner angle.

Down, or climb, milling shows a 3/1 improvement in tool life over up, or conventional, milling in the slotting cuts. With conventional milling considerable vibration was noted in the milling setup even when light feed rates of 0.003 to 0.005 in. per tooth were used.

Fig. 11 shows the tool life curve obtained when slot milling 52 R_c 4340 steel. With a 6-tooth cutter it was possible to mill a 1/4 in. deep slot 225 in. long at a cutting speed of 190 fpm and a feed of 0.005 in. per tooth. Considerable vibration was encountered when feeds of 0.008 in. per tooth and higher were attempted.

Drilling Tests

The drilling tests performed on the ultra-strength alloys consisted of drilling 1/4 in. diameter by 1/2 in. deep through holes. Drill life end point was an arbitrary 0.015 in. wearland on the drill margin or complete breakdown, whichever occurred first.

Drilling tests made on AISI 4340 steel with hard-

nesses of 50-55 R_c demonstrated that workpiece hardness was critical with respect to tool life when drilling with high-speed steel drills (see Fig. 12). With a T-15 drill, a cutting speed of 30 fpm, and a feed of 0.001 in. per rev. drill life was 100 holes for a workpiece hardness of 50 R_c, 30 holes for a workpiece hardness of 52 R_c, and only 5 holes for a workpiece hardness of 55 R_c.

To attain maximum drill life for the hardened steels, it is extremely important to keep drill length at a minimum. Emphasis must also be given to keeping the entire drilling setup as rigid as possible. Results of drilling tests with high-speed steel drills on 50 R_c and 52 R_c 4340 steel are shown in Figs. 13 and 14.

Tapping Tests

Fig. 15 shows that a good tap life of 146 holes was obtained in tapping 50 R_c 4340 using a standard M-10 4-flute taper tap, a highly chlorinated oil, a cutting speed of 5 fpm, and 60% thread. However, for the same cutting condition, tap life decreased markedly to 18 holes for a 70% thread, and only 13 holes for a 75% thread (see Fig. 16).

Tapping of 52 R_c 4340 steel proved to be considerably more difficult than tapping 50 R_c 4340. Using a standard M-10, 4-flute taper tap, a cutting speed of 5 fpm, and 60% thread, the best tap life obtained with any of the commercial types of cutting fluid tried was only 8 holes. The use of inhibited

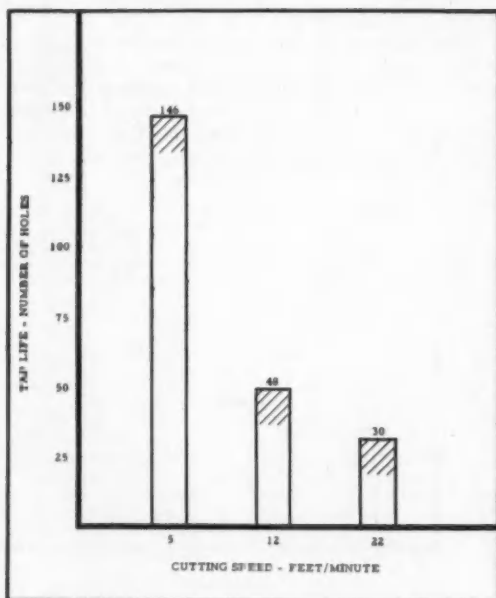


Fig. 15—Tapping 4340 steel quenched and tempered to 50 Rockwell C. Tap: 5/16-18 NC 4-flute taper; tap material: M-10 HSS; percent thread: 60%; depth of hole: 0.500 in.; cutting fluid: highly chlorinated oil; end point: tap breakage.

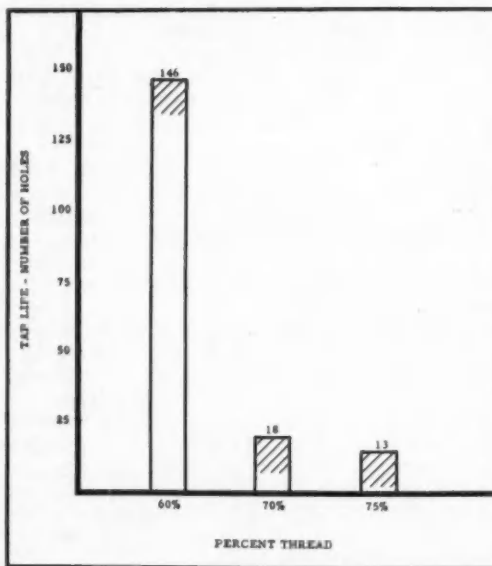


Fig. 16—Tapping 4340 steel quenched and tempered to 50 Rockwell C; effect of percent thread. Tap: 5/16-18 NC, M-10 HSS 4-flute taper; cutting speed: 5 fpm; depth: 0.500 in.; tapping compound: highly chlorinated oil; end point: tap breakage.

1, 1, 1 trichloroethane as a cutting fluid resulted in an outstanding increase in tap life to 75 holes (see Fig. 17).

Special precautions should be taken when using inhibited 1, 1, 1 trichloroethane as a cutting fluid since it is volatile and toxic. The maximum allowable concentration in air of this solvent vapor per million parts of air is 500, as compared to 25 parts per million of carbon tetrachloride.

Fig. 18 shows the effect of tap design and surface treatment of taps in tapping 52 R_c 4340 steel. All tests were made using a cutting speed of 5 fpm, 60% thread, and a cutting fluid made up of 3 parts of highly chlorinated oil and 1 part of inhibited 1, 1, 1 trichloroethane. Best tap life of 18 holes was obtained with an M-10, 4-flute taper tap with a 0.015 in. land. Preliminary tests have indicated that tap life can be further improved by nitriding M-10, 4-flute taper taps.

To Order Paper No. 43R . . .

... on which this article is based, turn to page 6.

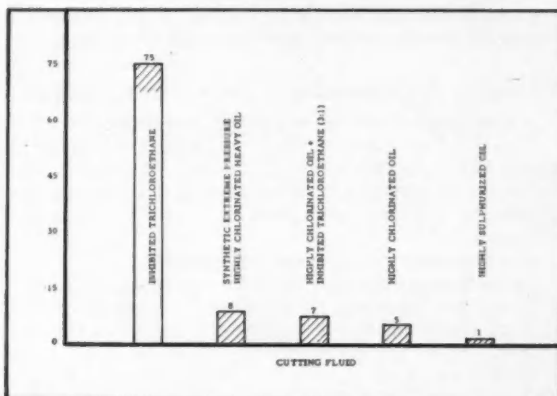


Fig. 17—Tapping 4340 steel quenched and tempered to 52 Rockwell C; effect of cutting fluid. Tap: 5/16-18 NC 4-flute taper; tap material: M-10 HSS; cutting speed: 5 fpm; percent thread: 60%; depth of hole: 0.500 in.; end point; tap breakage.

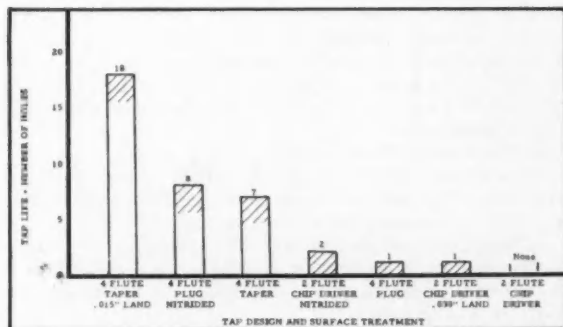


Fig. 18—Tapping 4340 steel quenched and tempered to 52 Rockwell C; effect of tap design and surface treatment. Tap: 5/16-18 NC; tap material: M-10 HSS—standard and nitrided; cutting speed: 5 fpm; percent thread: 60%; depth of hole: 0.500 in.; cutting fluid: highly chlorinated oil + inhibited trichloroethane (3:1); end point; tap breakage.

Go-Karts Provide Racing Thrills with 2½ Hp

Based on paper by

LYLE FORSGREN

Graduate student, University of Michigan

(Presented before the SAE Northwest Section)

GO-KARTS are small, single-seat racing machines that boast neither bodies nor spring suspensions. (See Fig. 1). They are generally powered by 2½-hp engines and have a top speed of about 30 mph. After the thrill of the first ride, racing seems to be the most popular kart activity. Generally, the race is over a simulated road circuit that has been set up on a parking lot, although the traditional American oval is also used.

As with any sport, rules had to be made before serious competition could be considered. Since the sport is still in its infancy, the rules are subject to revision but in general they are as follows:

Wheelbase, in.	40-50
Tread	2/3 wheelbase
Maximum Overall Length, in.	72
Engine	2-stroke
Displacement, cu in.	
Class A	Up to 5.8
Class B	5.8-11.6
Class C	11.6-16.5

No body

Two-wheel brakes on Class B & C Karts

One-wheel brakes on Class A

Tires—12.5-in. maximum diameter, pneumatic

Gasoline for fuel

Frame—all metal including firewall

Various common sense safety rules are also included.

To Order Paper No. S192 . . .

on which this article is based, see p. 6.

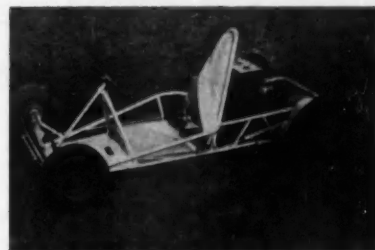


Fig. 1—Mk V go-kart was built with a space frame type of construction. Few cross-members were used, so torsional rigidity of frame was low, while vertical bending was kept to a minimum. Brake has 6-in. diameter drum, 2 in. wide. Diaphragm-type carburetors are used, with attached diaphragm fuel pump, which is actuated by crankcase compression.

How the

T53 Anti-Icing System

Was Developed

Based on paper by

T. A. Dickey, O. Dumler, and J. R. Untied

Lycoming Division, Avco Mfg. Corp.

LYCOMING designed the T53 anti-icing system to prevent engine damage and sudden loss of power. Engine icing—which can occur at ambient temperatures as high as 41 F—is more rapid, more damaging, and less obvious than airframe icing. But it is more easily prevented, too.

Conditions for anti-icing protection

The T53—a free-turbine, shaft-power engine in the 860-1000-hp class—had to meet military requirements. These specify that neither loss of power nor increase in fuel flow shall exceed 5% due to icing—or to the anti-icing system—under the

defined conditions. The specifications define only a sea level condition. But an anti-icing system that meets the specs at sea level will work satisfactorily at all helicopter altitudes.

Fig. 1 shows the two conditions defined by the military, together with those of the Civil Aeronautics Board.

An engine test cycle, also specified by the military, defines the amount and sequence of low power operation—the critical design area. Fig. 2 shows the required power settings and the T53 rotor rpm.

Choosing the anti-icing system characteristics

• Continuous or “as required” operation?

The T53 has a noncontinuous system—except for struts through which hot oil passes. Lycoming ruled out a continuous system because it imposes an unnecessary performance penalty over 95% of useful engine life.

• Automatic or manual operation?

Lycoming leaves the decision to equip the engine with an ice detector (which turns on the automatic system when there are icing conditions) to the customer.

Detectors are currently incorporated in the T53-L-1 and T55-L-3 helicopter engines, but not in the T53-L-3 turboprop or in the T53-L-5 helicopter engines.

• Range of engine power over which anti-icing should be effective.

The T53 system meets test cycle performance at all speeds except ground idle; at this speed the system is protected at temperatures above 25 F. This ability prevents ground operation difficulties during a freezing rain, the only situation needing anti-icing protection at ground idle. Fig. 3 shows the effective operating range of the T53 anti-icing system for continuous operation.

• Performance penalties.

The system installed in the T53 meets military requirements for increase in fuel flow, and causes considerably less power loss.

• Weight and complexity of system.

The design is as simple and light as possible; and does not compromise the efficiency or optimum design of the engine.

Areas to be protected

Because of complex inlet geometry, Lycoming bypassed theory and began experiments early in engine development to determine which surfaces re-

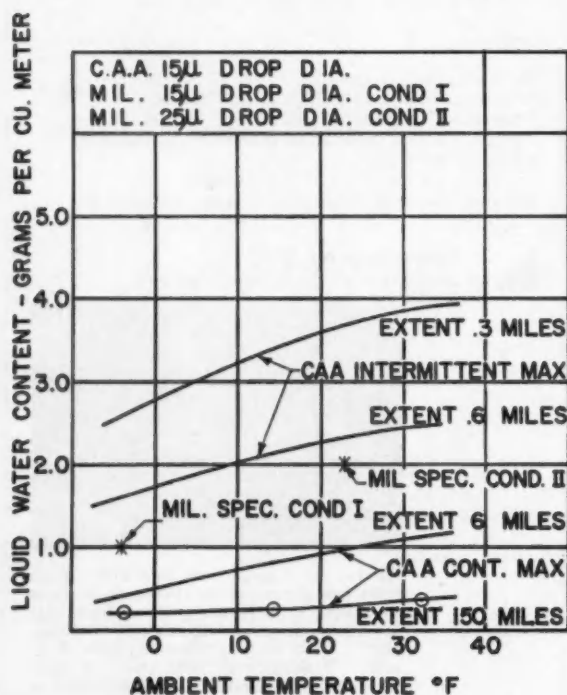
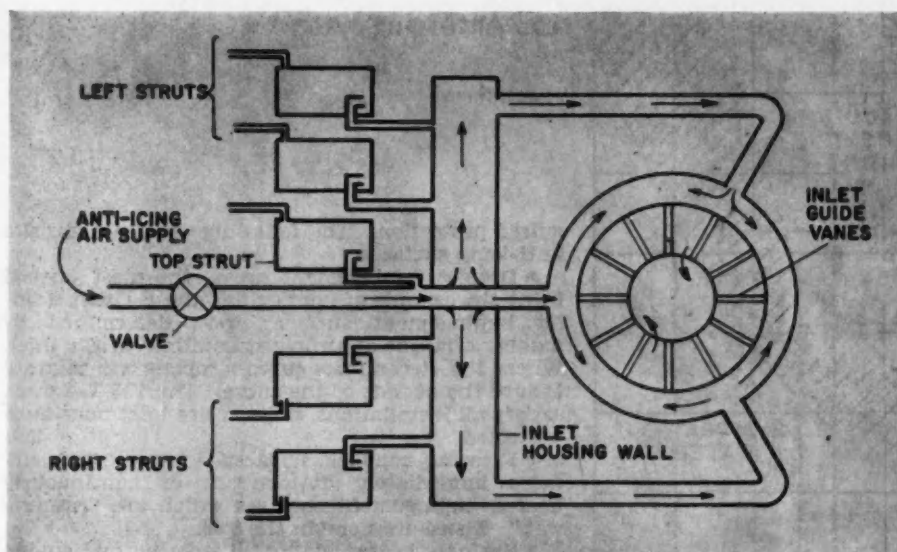
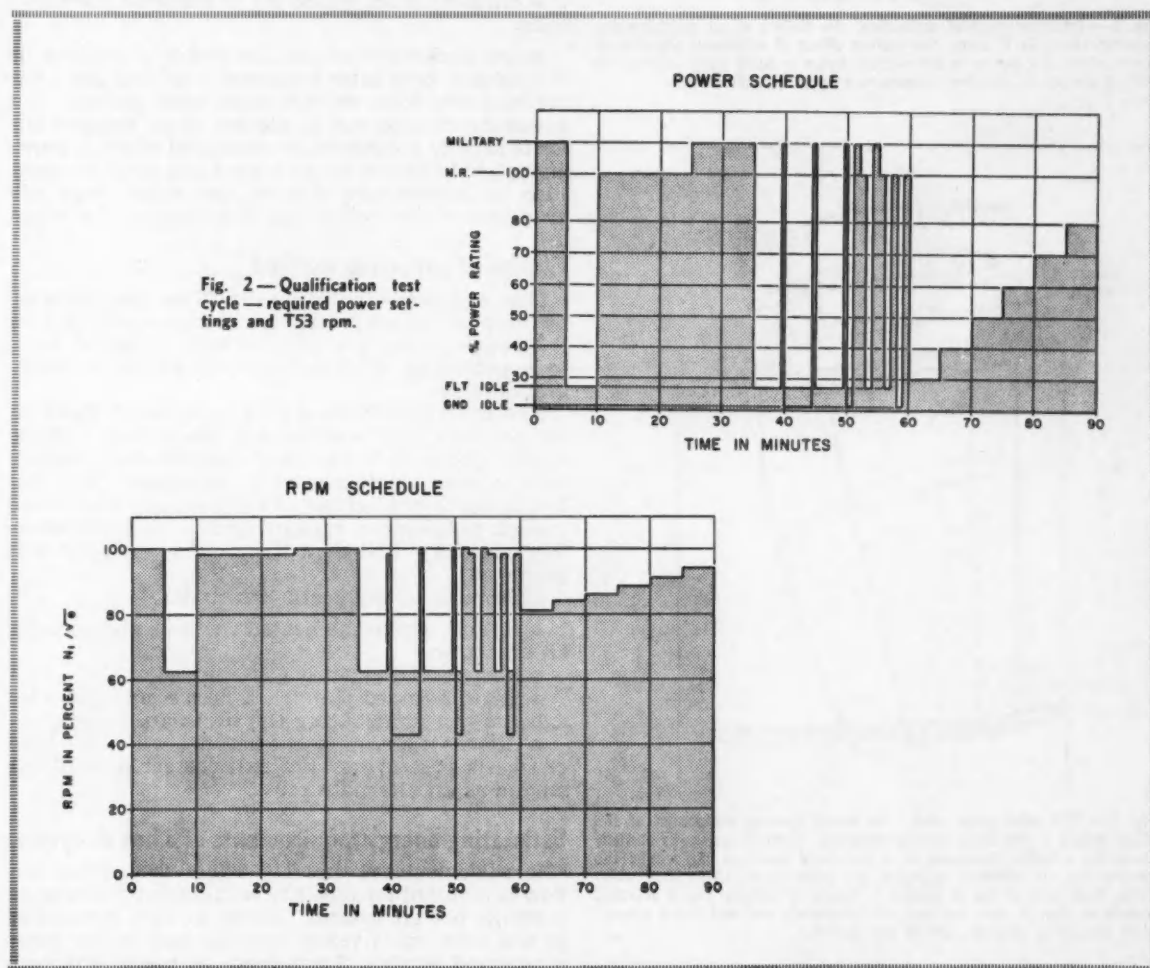


Fig. 1 — Military and CAB specifications of atmospheric icing conditions.



T53-L-3 hot air circuit combines parallel circuits with a series circuit (the inlet housing wall). The latter supplies the struts, and augments the flow to the guide vanes.



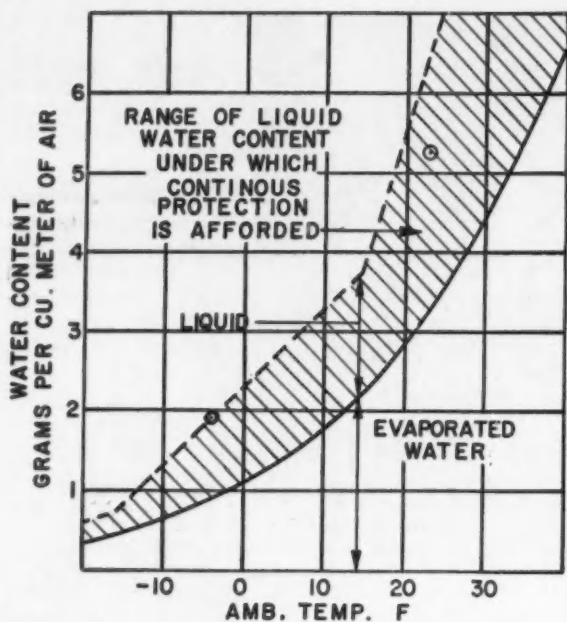


Fig. 3—Effective range of protection. No limit is shown on the water content above 25 F, since the cooling effect of additional amounts of water above 2 g per cu m are slight. Below a liquid water content of 0.15 g per cu m, the low temperature range is unlimited.

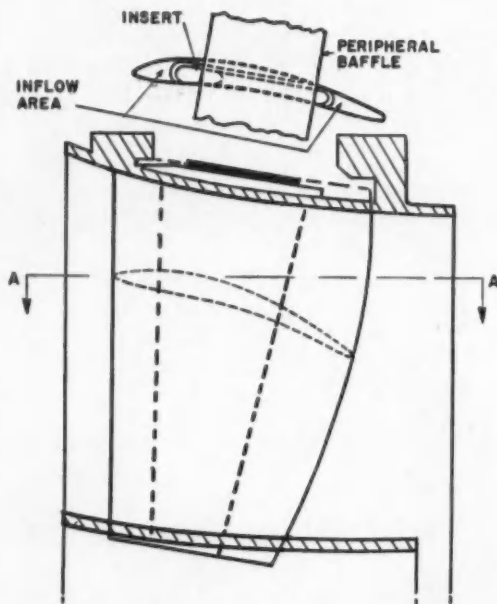


Fig. 4—T53 inlet guide vane. An insert running the length of the blade divides it into three parallel passages. Central passage is partially closed by a baffle, consisting of a peripheral band running around the annular hot air manifold supplying the guide vanes. The band width varies from wide at top of engine to narrow at bottom, and is attached loosely so that it does not seal off completely any mid-chord passage even though it extends beyond the inserts.

T53 Anti-Icing System

... continued

quired protection. The following are characteristic anti-icing surfaces:

- Droplet impingement areas, the most critical being the cascade of inlet guide vanes. Other droplet impingement surfaces were determined by making a layout of airflow streamlines in the inlet. Where the streamlines curve, droplets will migrate toward the outside of the curve. The T53-L-3 must satisfy all installations, so its entire inlet housing is protected.

- Freezing runback surfaces—unprotected surfaces immediately downstream of continuously heated impingement surfaces which are "running wet." There are none in the T53.

- Surfaces heated by hot oil from normal engine operation, which include the reduction gear housing and the lower strut.

- Surfaces from which ice is removed mechanically.

Rotor blades accumulate ice which is removed by centrifugal force after it reaches a critical size. Accretions also form on the compressor stators. But Lycoming elected not to protect them because the ice is usually mechanically shattered when it grows enough to be struck by the rotor blade trailing edges. Also, a temperature rise on the rotor stage will evaporate the droplets not removed by the rotor.

Choice of anti-icing method

Most engines—including the T53—are protected by bleeding hot air from the compressor and passing it through passages within the walls of the surfaces to be protected. This system is the easiest to design and develop.

The main drawback is that compressor bleed air temperature and pressure are too low at reduced engine power to adequately protect small airfoils having even smaller internal passages. But this limitation is not serious if the surfaces are heated enough to tolerate a reasonable time at flight idle—five minutes—and clear themselves when power is reapplied.

Alternates to this method include:

- Hot oil, where the heated surfaces also serve as an oil cooler.

- Hot air and exhaust gases mixed.

- Hot air passed through a heat exchanger with exhaust gas contributing the necessary energy.

- Alternate air, or charge heating, where the inlet charge is passed over hot exterior surfaces of the engine as an alternate route.

Estimating energy requirements of a hot air system

It was calculated that 1½–2% of T53 engine airflow is required for effective anti-icing protection in a simple hot air system. About 60–70% is required in the inlet guide vanes, and the rest in the three air-heated struts. There were so many unknown

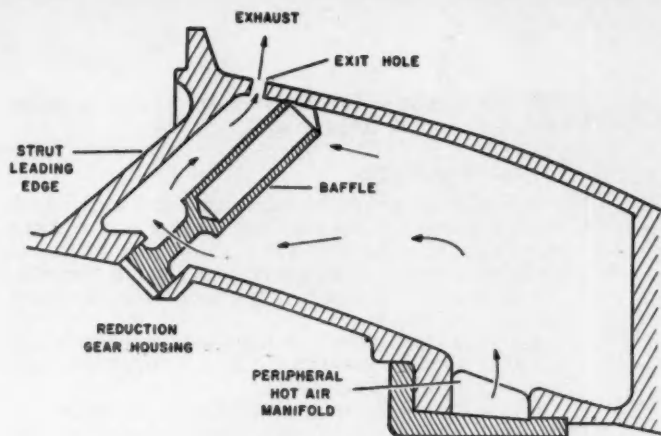


Fig. 5 — (above) T53-L-1 hot air route in lateral strut. (right) T53-L-3 hot air route. Air is supplied through a manifold on outside of inlet housing.

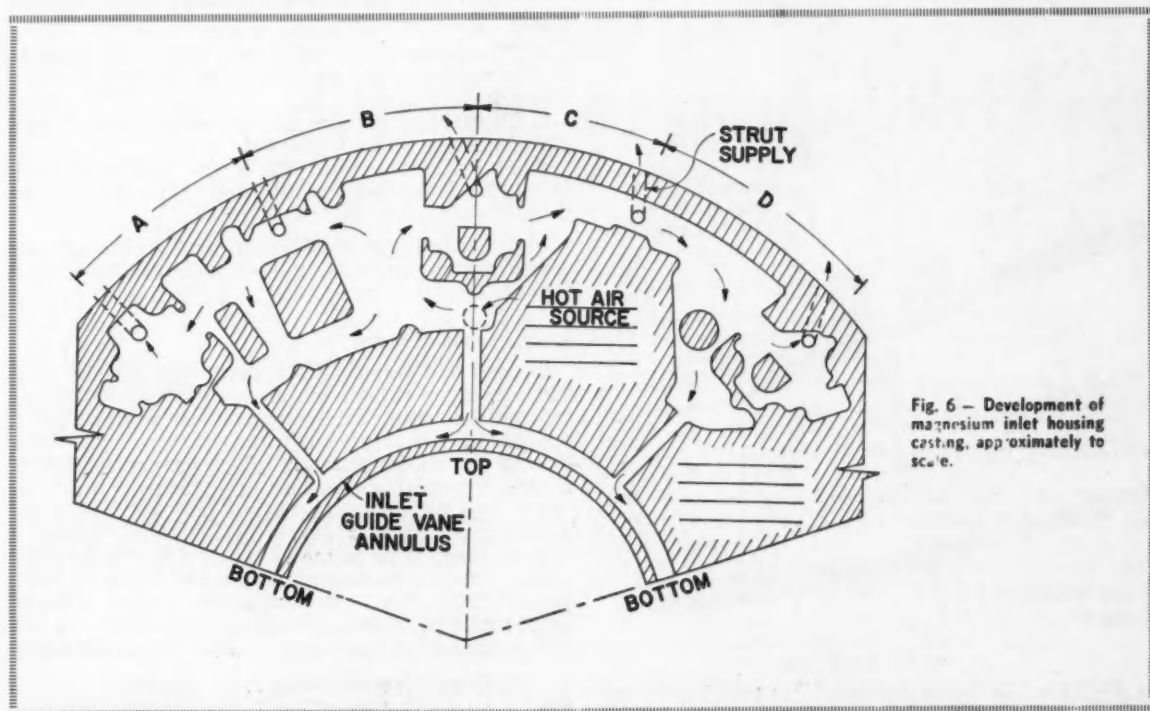
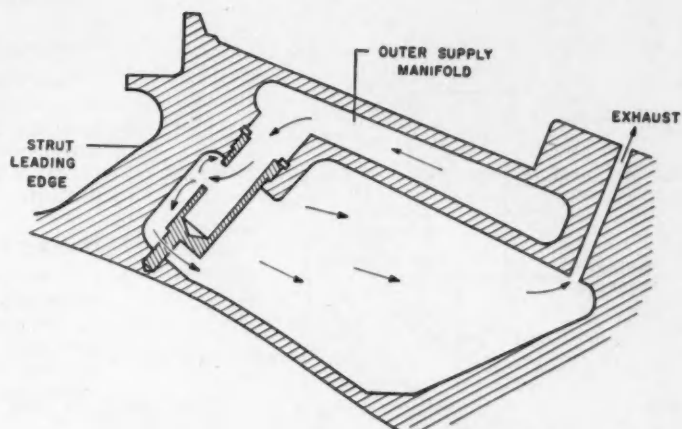


Fig. 6 — Development of magnesium inlet housing casting, approximately to scale.

T53 Anti-Icing System

... continued

quantities, that the calculated estimates were inadequate. Development was on a cut-and-try basis, and the final configuration little resembled the calculated one.

Layout of the hot air circuits

The T53-L-1 circuit is basically four parallel paths—one for each strut and one for the guide vanes. The schematic at the top of page 47 shows the

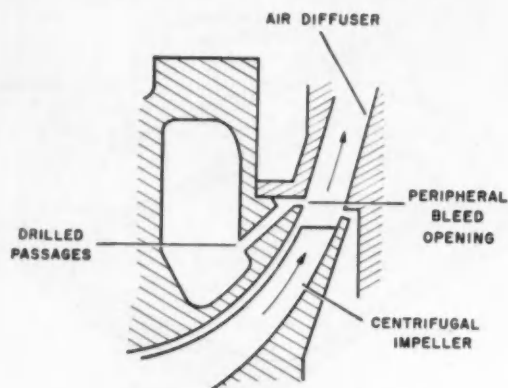


Fig. 7—Bleed air extraction passages.

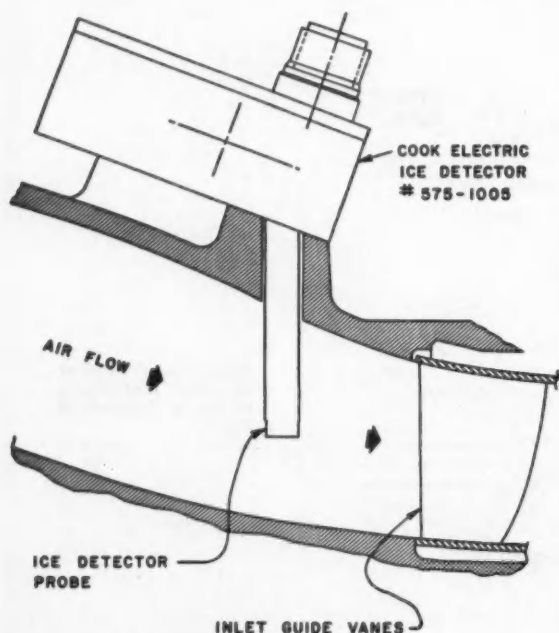


Fig. 8—T53-L-1 ice detector installation. The probe is swept back 20 deg to improve ice-shedding characteristics.

T53-L-3 system—the above system plus a series circuit, the inlet housing wall.

Layout of passages

- A hollow inlet guide vane, used as a single pass tube, is unequally heated; the leading and trailing edges remain cold. The T53 solution (Fig. 4) was to maintain a single pass, but restrict flow in the mid-chord area and promote high velocities at the leading and trailing edges.

- Struts are hollow and filled with hot air or hot oil. Fig. 5 shows the T53-L-1 and T53-L-3 systems, which function equally well.

- Testing proved that anti-icing is necessary for an inlet housing used with straight inlet scoops. Lycoming developed an inlet housing casting having a cored air passage. (Fig. 6.)

Pressure drop and regulation

The T53 system uses a combined on-off valve and regulator which reduces flow area as the flow increases. It does not achieve constant flow, but does compensate for the tolerance difference in hot air passage cross-section, tending to make all engines uniform.

Hot air extraction passages

The configuration (Fig. 7) aims at uniformity of extraction around the periphery of the compressor to prevent hot spots in the combustor. Location of the point of extraction does not permit recovery of velocity of air leaving the impeller, but is superior from a mechanical design standpoint.

Ice detector installation

To determine the detector location, the following points were considered:

1. The probe should be located as close as possible to the most critical surface to be protected—the T53 inlet guide vanes.
2. The stream velocity should be as high as possible where the probe is located.
3. The surface from which the probe projects should be protected against icing. The probe must be insulated from heated surfaces.

Fig. 8 shows the installation of the T53 ice detector, which operates by the "total-pressure" system.

Retractable screens

Retractable screens were developed for the first T53 turboprop version. A pressure switch which retracted the screen when the pressure drop across it exceeded a set value was unsatisfactory. This was due to the wide variation in screen pressure drop normally present as a result of variations in engine speed and altitude. Lycoming has not continued development of this device because the screen is now an item of airframe responsibility. Also, tests indicate that with sufficient space available, a helicopter screen can be designed with enough area to be insensitive to ice. If aircraft requirements are not stringent, a fixed screen may be satisfactory.

To Order Paper No. 495 ...

... on which this article is based, turn to page 6.

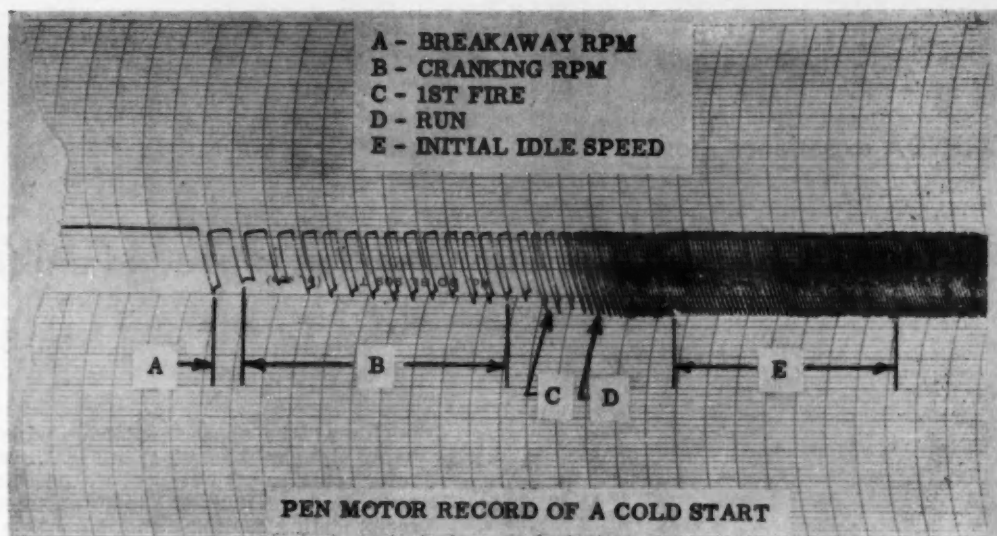


Figure 1

At Ford . . .

ONE RECORDING gives all data on engine cold test

Based on paper by **Carl C. Runyon**
Ford Motor Co.

ALL data in Ford laboratory cold-starting test procedures are drawn from a single recording.

This recording is made with a pen motor recorder. It records impulses of the distributor breaker points as a function of time on tape. Engine cranking speed, time to first fire, and time to be run can be calculated to 1/10 sec.

Fig. 1 shows a pen-motor recording of ignition impulses, which is used to get the quantities used in the following formula:

$$\frac{60}{D} \times \frac{\text{Impulses}}{\frac{1}{2} \text{ number of cylinders}} = \text{rpm}$$

where:

60 = Constant chart speed of 60 in. per min
D = Distance

Therefore:

A. Breakaway rpm = fifteen divided by the time interval between the first and second impulse. Fifteen because this is an 8-cyl engine.

B. Initial cranking speed = fifteen divided by distance times impulses for approximately three seconds after breakaway.

C. Time to first fire = time interval from first impulse to first fire.

D. Time to run = time interval from first impulse to time when engine runs without the aid of the starter motor.

E. Initial idle speed = number of impulses per second times fifteen. Fifteen for 8-cyl engines.

Driveaway tests are conducted on the chassis dynamometer after the cold start is made.

To Order Paper No. 305 . . .

... on which this article is based, turn to page 6.

Accurate dirt detection is needed aid to better

Based on paper by

A. L. Sutton

Orenda Engines, Ltd.

IF contamination of fuel in aircraft engines can be accurately detected, equipment already exists to cut it to a fraction of what is considered acceptable today. But "accurate" means indication of fuel contamination levels in the order of 1-5 mg per gal. . . and in most cases so far, fuel contamination has been measured only where it existed in excessive amounts. Until very recently, in fact, contamination has been detected and measured by operators chiefly by its effect on the engine fuel system — in particular, the fuel pump.

Orenda engine experience with service fuels has taken place under conditions which brought problems closely parallel to those of civil turboprop operators. But operating conditions of Orenda's critical components are far more severe in the fighter aircraft where they are used. Also component life data are somewhat less reliable.

Many interesting indications are to be derived from Orenda's experience.

The Mechanism of Failure

A sizable number of failed pumps were examined, for example, without disclosing the mechanism of failure. Study of the problems involved shows this not to be as odd as it might seem at first glance. For instance:

- The rotating parts of the pump are inaccessible for examination in the field.
- With the quantities of fuel handled, pump casing temperature gives no indication of pending failure.
- Pumping efficiency decreases very little before ultimate failure — which normally shears the drive-shaft.
- With the power available, increases in torque cannot be detected.
- Failure, when it occurs, is generally extremely complete and leaves little useful evidence.
- The obvious failure area lies in the lubrication problem in one of three areas: (1) the pump plunger in the rotor; (2) the plunger spherical head in its slipper; or (3) the slipper pad on the camplate. Failure in any one area will greatly destroy the others.

This will be appreciated from examination of a pump plunger in detail, as in Fig. 1. With the pump rotor rotating with respect to the camplate, it appears that the plunger slipper assembly, besides its reciprocating pumping motion, has a tendency to rotate. Slipping will occur in one or all of the three bearing areas, depending upon the friction and loading that exists.

Initially, the failure mechanism was thought to initiate with the slipper on the camplate until the piston head came into contact with the camplate. Later it appeared that the piston spherical head was wearing up through the slipper. At present, possibly as a result of cleaner fuel, heaviest wear appears in the rotor bores. In any event, it can be readily seen that the mechanism of failure is quite complex.

The mystery is: How can fuel contaminated to an unknown degree — but surely not more than 60-70 mg per gal — produce failure in less than 100 hr of field operation, when 200 mg per gal took about the same time to fail a pump running continuously under overloaded conditions?

Inferred here is that the fully loaded condition is not the most susceptible to contamination . . . or that service-type contamination may be several times as vicious or plentiful as the laboratory type. The likeliest possibility seems to be the few pumps that failed early actually had longer life than recorded . . . and had been subjected to heavy contamination for lengthy periods.

For example, in one operator's experience, installation of a new hose on a refueling tender raised the contamination level from about 2 mg per gal to 65 mg per gal. Flushing with 10,000 gal of fuel was required to bring it back slowly to the 2 mg level. Occasional failure of a fuel tank filter would permit short-time supply of even more contamination to an aircraft.

Most promising of the experimental changes was the introduction of silver sleeves into the pump rotor bores instead of cadmium plating. One-hundred such modified pumps were installed on operating engines to assess the field value of the idea. This experience showed an increased average pump life of 60-100% — and the modification is being incorporated in all pumps.

Inclusion of a 5-micron main low pressure filter within the engine fuel system had little effect.

Orenda's rather limited experience leads to the belief that the millipore membrane filter technique

Cleaning of Dirty Fuels

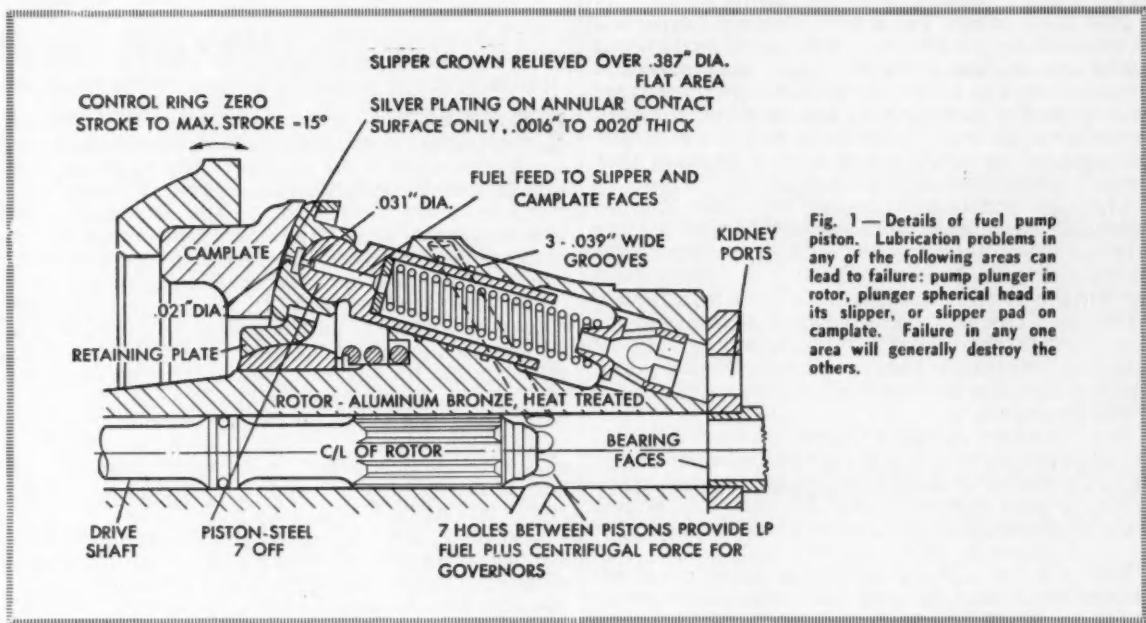


Fig. 1—Details of fuel pump piston. Lubrication problems in any of the following areas can lead to failure: pump plunger in rotor, plunger spherical head in its slipper, or slipper pad on camplate. Failure in any one area will generally destroy the others.

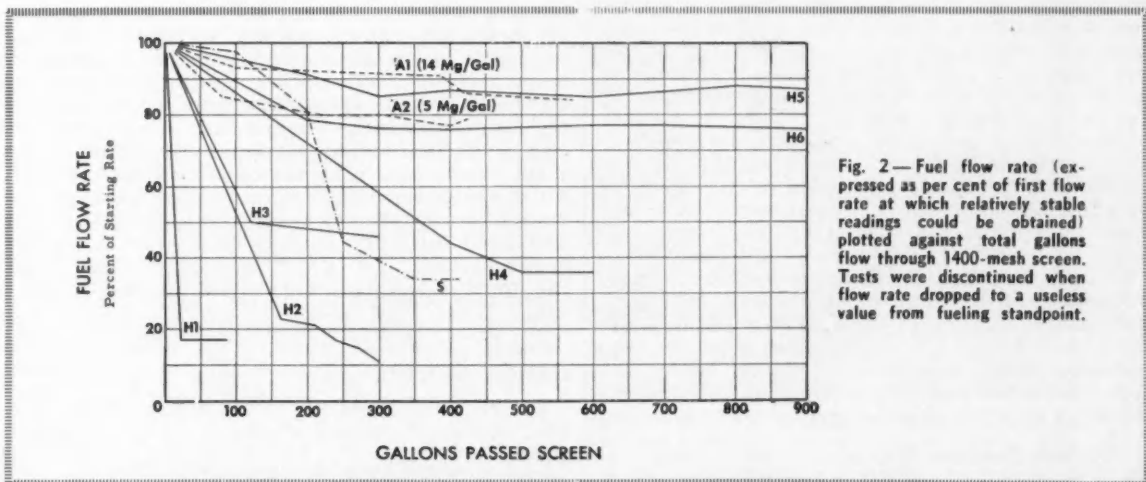


Fig. 2—Fuel flow rate (expressed as per cent of first flow rate at which relatively stable readings could be obtained) plotted against total gallons flow through 1400-mesh screen. Tests were discontinued when flow rate dropped to a useless value from fueling standpoint.

Cleaning of Dirty Fuels

... continued

is the best to date ... although too exacting a procedure to be of any real value in military operations.

Orenda also carried out some rough and ready checks at several bases from which their aircraft were operating. Tests were made by inserting a 60 sq in. screen of 1400 mesh in the fueling nozzle.

1400 mesh screen has a wire opening (centerline to centerline) of 0.0007 in. Wire diameter is about 0.0005 in., so the *projected* open area measures roughly 0.0002 or 5 microns square. With the large wire diameter compared to the opening, the projected area has little significance, and the generally accepted cutoff point — the size of particle that cannot pass the screen — is 17 microns.

The tests consisted of noting the effect on flow rate and examining the debris retained on the screen. The interesting and surprising results are shown in Fig. 2. Here the fuel rate is plotted (as a percentage of the first flow rate that permitted a relatively stable reading) on a base of total gallons flow through the screen — starting where the flow rate was obtained. Tests were discontinued when the flow rate had dropped to a useless value from a fueling standpoint.

In cases where millipore membrane tests were run at the same time, no particular relationship to the flow rate tests were indicated. This is logical, since a fuel heavily contaminated with particles of less than 10-micron diameter should have, theoretically, no blockage on the 1400 mesh screen.

Here, the real point of interest is: Though a fairly acceptable level of contamination was shown by all millipore membrane tests, sufficient "large" particles were in the "filtered" fuel to severely reduce flow through the 1400 mesh screen. This "filtered" fuel had passed twice through 5-micron filters and was blocking a 17-micron cutoff screen. No criterion of a particular filter is meant. The test locations were widely separated and involved various fuel suppliers ... settling times, filter maintenance, and so on, being quite unknown. Both military and civil installations were checked.

Orenda, as a jet engine manufacturer, acknowledges responsibility to provide an engine and fuel system with maximum resistance to the effects of dirty fuel. But high-speed, high-pressure, high-precision equipment will always operate better and longer on clean fuel than on dirty fuel.

Ground equipment for cleaning fuel can be bulky and heavy and of almost indefinite life. Jet engine fuel systems are none of these, and all efforts to design to accommodate contamination must result in increased weight and lower efficiency. While the engine manufacturer must strive to resist contamination, so must the operator strive to reduce it.

To Order Paper No. 475 ...

... on which this article is based, turn to page 6.

More Efficient Trailers

Based on paper by Mitchell A. Kapland

The Englander Co., Inc.

REFRIGERATION trucks and trailers sometimes carry as much as 1500 lb of ice in their insulation, due to inward ram air leakage. And as much heat can be lost through the fasteners and metal supports as through the rest of the insulated body. The obvious difficulties of these problems are now being tackled through the development of new insulation materials and new vehicle design concepts.

Moisture accumulation in the floors and walls causes ice formation in the trailer, as shown in Fig. 1. Moist air enters at the bottom of the truck, rises, and deposits its moisture, which then becomes ice. Moisture in the floor collects after the ice thaws when the truck is not operating. The effect of the extra weight of the ice on the load-carrying capacity of the truck is obvious. Also, water gives off 144 Btu of latent heat per pound as it changes to the solid state at 32 F.

Currently, the best approach to the problem is the use of fiberglass plastic for the highly structural members such as floor beams, and other plastics for the less critical items (such as supports for wall liners). The problem is one of finding a material which is satisfactory from both the insulation and structural standpoints.

Various other solutions have been suggested: (1) bagging of fibrous types of insulation in vapor barrier materials such as plastic films, and (2) sealing the inside of the aluminum shell. Neither method is entirely satisfactory — the former because it is difficult to install without damaging the bags, and the latter because it is nearly impossible with current production techniques to seal the joints of the sheet *completely*. The use of styrene-type foams, which are impervious to moisture, is also somewhat unsatisfactory: the blocks must be tailored to fit the individual truck and must be held up by structural members which add weight and complexity. And the joints of the foam are possible sources of leakage.

design concepts

Several new types of reefer construction have been developed that are worthy of serious consideration.

One is the foam-in-place insulation, which uti-

Refrigeration

Coming

lizes urethane. (See Fig. 2.) The foam is fed into the trailer through a hose until the entire cavity is uniformly filled. The difficulties of the method are:

1. Filling the cavities evenly to leave no air pockets requires considerable skill on the part of the operator.
2. The equipment necessary is elaborate and expensive.
3. The presence of structural fasteners and posts, with the resulting problem of conductivity.

The conductivity of metal is a big factor in heat transfer. *K* factor is a measure of a material's value as an insulator — the lower the number, the better the insulating value. The factor is derived by calculating the number of Btu per hour which pass through an inch thickness of a square foot of the material for each degree Fahrenheit change in temperature. Table 1 gives the *K* factor of several currently used materials.

From this table, it is easy to see how aluminum sidewall posts would nullify the effect of a large amount of the foam-in-place insulation.

The foam-in-place idea has been applied to modular panels which can be factory-made in various sizes and then installed in the trailer. Quality control is much easier in this method than in the direct installation of foam into the trailer walls. Also, cost is lower.

Advantages of the modular panels are:

1. The differential heat gain on the body shell is dissipated through a free air space between the panels and the outside trailer skin.
2. The impermeable foam core of the panels prevents the forced circulation of ram air in the insulation and precludes the accumulation of moisture.
3. Ease of repair.

The main disadvantage is the danger of air leakage through the joints between the panels.

The modular panels are the best current approach to meeting the criterion that an efficient insulating system must "effectively impede the transgression of heat from ALL sources under ALL operating conditions at a minimum burden of weight and volume."

To Order Paper No. 16S . . .

. . . on which this article is based, turn to page 6.

Table 1 — Relative Heat Transmission Values of Various Materials

	<i>K</i> Factor
Aluminum	1300-1400 (average)
Stainless Steel	105
Ordinary Steel	312
Fiberglass Plastic	2.2
Wood	0.75
Fibrous Insulations	0.28
Styrene Foams	0.25
CO ₂ Urethane Foam	0.19
Freon Urethane Foam	0.14

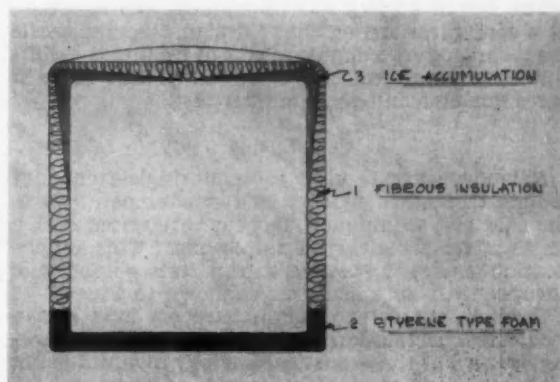


Fig. 1 — Ice accumulation is common in present-day trailer insulation. Moist air enters through joints on panels and fasteners, rises, and then deposits condensate as the truck goes into operation. Prevention of this accumulation is one of the aims of new insulation ideas.

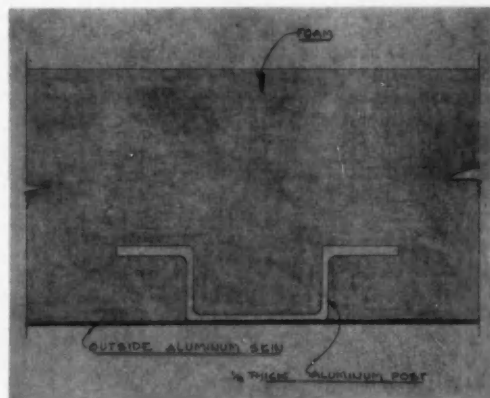


Fig. 2 — Foam-in-place insulation fills the cavity between the inside and outside skins of the trailer with urethane foam. When properly installed the foam completely fills the cavity, preventing most air leakage.

Two new test techniques produce

Simplified Muffler

TWO new test techniques are helping the muffler designer keep ahead of the ever-growing demands on car muffler systems: They are cold acoustical testing and resonant-pipe sound-velocity measurements.

The first is a quick and economical way to screen new configurations or check design changes, while the second offers a simple means of finding the difficult-to-measure velocity of sound of hot exhaust gases during a full-scale muffler test.

Cold Testing

A loudspeaker is used to send single-frequency sounds through a muffler at room temperature in the cold test technique. Testing is repeated over a series of frequencies and amplitudes. This simplification makes it possible to run tests quickly and cheaply with an apparatus as shown in Fig. 1.

Tests on simple expansion chambers have shown reasonable correlation with actual tests of hot-flowing-gases, but the acoustical analogy involved is not yet understood completely enough to produce more than occasional correlation on complete muffler systems.

The attenuation curve of even a simple system is difficult to calculate and expensive to find, experimentally, with hot-flowing exhaust gases. The

"cold" method produces the curve as quickly as the adjusting of an oscillator produces different frequencies. An example of the accuracy of the technique is given in Figs. 3 and 4 for the chamber shown in Fig. 2. (A 2-ft tailpipe was added to the chamber in calculations and tests.)

The attenuation for the chamber-tailpipe system was calculated to be:

$$\text{Attenuation} = 10 \log_{10} \left[1 + \frac{(m^2 - 1)^2}{2m^2} \sin^2 kl_e - \frac{m^2 - 1}{2m} \sin 2kl_i \sin 2kl_e - \frac{m^4 - 1}{2m^2} \cos 2kl_i \sin^2 kl_e \right]$$

where:

$m = \frac{s_2}{s_1}$ = Expansion ratio

$k = \frac{2\pi f}{c}$

l_e = Effective length of muffler

s_1 = Cross-sectional area of inlet and outlet tube

s_2 = Cross-sectional area of expansion chamber

f = Sound frequency

c = Sound velocity

l_i = Effective tailpipe length

Cold tests were run at frequencies from 75 to 300 cps. The calculated and cold-test values matched well, as seen in Fig. 3.

Engine tests were run at 2200 rpm and 72 lb-ft torque. The noise spectrum was analyzed and an attenuation curve derived. The actual sound velocity for the engine test was 1600 fps. The cold test data are corrected for this velocity by scaling the cold frequency in direct proportion to the ratio of sound velocities. This correction method is indicated by the theoretical equation because the only factor affected by sound velocity is k . To keep k constant, and thus the attenuation, the sound frequency must be changed at the same ratio as the sound velocity. The results of the engine and corrected cold tests show close enough agreement in Fig 4 so that the cold test could have been used to predict hot muffler performance.


How to Measure "Hot" Sound Velocity

A turning tube is the key to measuring the velocity of the sound of exhaust gases in the muffler system

This article is based on the following papers:
"Exhaust Systems, Fundamentals and Design Considerations," by L. E. Muller, Buick Motor Division. (Paper No. 38R)

"Cold Acoustical Tests of Mufflers," by R. R. Regelbrugge, Hays Industries, Inc. (Paper No. 38S)

Mr. Muller's paper also covers design information on exhaust noise spectrum, chamber location, resonators, multiple chambers, louvers, power losses, corrosion, connections, and vibration isolation.

 To Order Paper Nos. 38R & 38S ... turn to page 6.

Testing

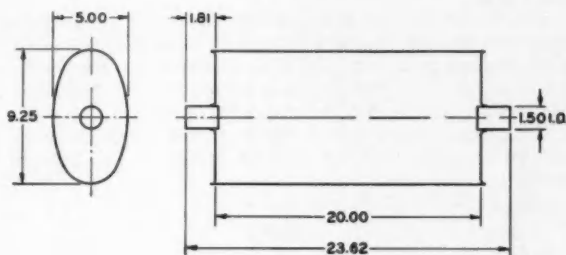


Fig. 2—Simple silencer expansion chamber can be used to check accuracy of cold test method. Attenuation curve of this chamber can be calculated theoretically, and measured by cold and engine tests. Results are shown in Figs. 3 and 4.

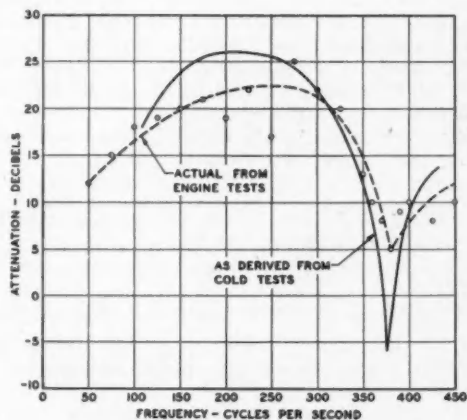


Fig. 4—Cold test results shown in Fig. 3 are first corrected for temperature and then compared to an actual engine test of the silencer expansion chamber. The temperature correction accounts for the right-hand shift of the cold test curve. Comparable accuracy has been achieved in only a few complicated muffler systems.

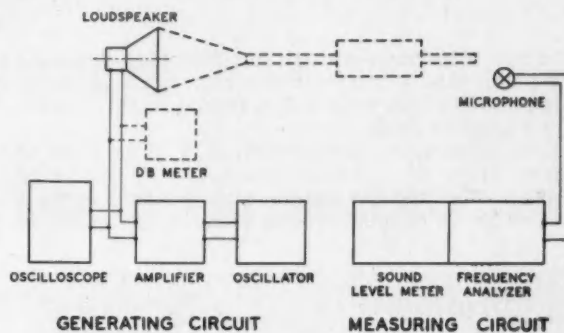


Fig. 1—Cold acoustical testing of mufflers produces usable attenuation curves and cuts cost and complexity of testing. Cold tests are used when the problem is acoustical in nature, tests are backed up with dynamometer and road tests.

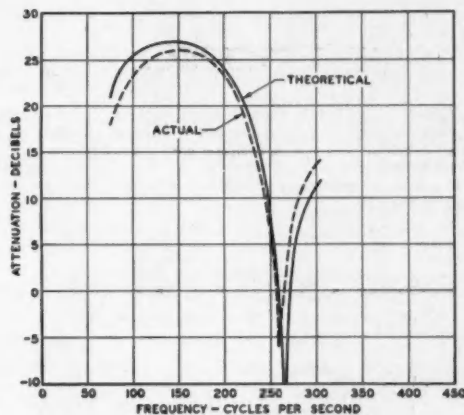


Fig. 3—Accuracy of cold test method shows up well when compared to theoretical calculations for chamber shown in Fig. 2 equipped with 2-ft tail pipe. This graph is for room temperature air in the chamber.

Simplified Muffler Testing

... continued

of a car. This measurement has defied solution for a long time due to the relatively high temperature of the gas. Yet, this velocity is a fundamental requirement in noise work.

The solution to the problem is a tuner such as shown in Fig. 5. The tuning tube, which is made the same diameter as the exhaust pipe, is placed at right angles to the exhaust system with the open end ex-

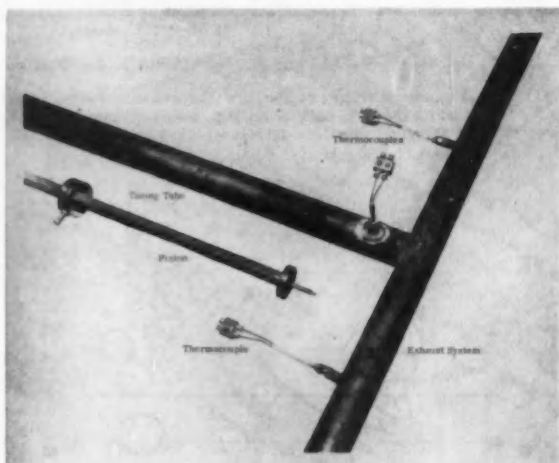


Fig. 5—Quarter wave length tuned pipe at right angles to the muffler systems gives a method of determining the velocity of sound of hot muffler gases. A piston is moved in the pipe until attenuation is at a maximum. The length of the tuned pipe can then be used to calculate the velocity of sound. Temperature measurements must be taken to correct for cooling in the pipe.

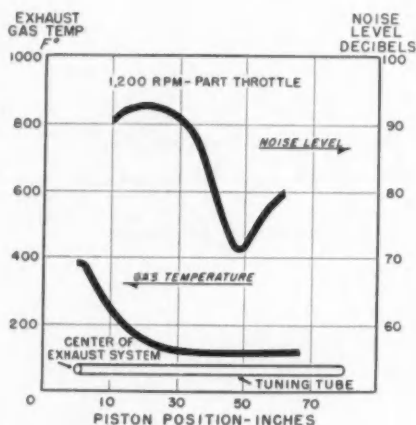


Fig. 6—Sharp V in the attenuation curve of the tuned pipe shown in Fig. 5 pinpoints the quarter wave length location. This length, along with the average temperature in the pipe, produces the velocity of sound calculation for the exhaust system.

posed to the exhaust gases. It is basically a "closed organ pipe" whose effective length can be changed by means of a movable piston. The adjustable piston is connected to a calibrated rod that indicates the piston's location from the "open" end of the tube. The theory of the tube's operation is that when the piston is adjusted to give maximum attenuation for silencing of a given frequency, the distance from the piston to the center of the exhaust pipe is one-quarter wave length of the frequency being attenuated.

However, a correction must be made for the difference in the temperature of the gas in the tube and the exhaust pipe. Therefore, thermocouples are installed in the tuning tube as well as the exhaust pipe. To keep the gas temperature in the tuning tube as uniform as possible, it is covered with an insulating material.

Since engine firing frequencies give such a strong signal, they are used in calculating the velocity of the sound.

Fig. 6 shows the attenuation of firing frequency attained by the use of the tuning tube while an engine was running at 1200 rpm under road load conditions. Also shown are the temperatures recorded in the exhaust pipe and tuning tube.

This attenuation curve shows the measured quarter wave length to be 48.5 in. long for an 80-cps sound.

Since:

$$V = F W_L$$

where:

V = Velocity of sound, fps

F = Frequency of sound, cps

W_L = Wave length, ft

the velocity of sound is then calculated as:

$$V = \frac{80 (48.4) (4)}{12}$$

$$V = 1292 \text{ fps}$$

As the temperature of the gas in the tuning tube is less than the temperature of the gas in the exhaust system, and since the velocity of sound varies as the square root of absolute temperature, a more correct velocity will be found by use of the following equation:

$$V_R = V_T \sqrt{\frac{T_R}{T_T}}$$

where:

V_R = Velocity of sound in the exhaust system, fps

V_T = Velocity of sound in the tuning tube, fps

T_R = Absolute gas temperature in the exhaust system, R

T_T = Absolute gas temperature in the tuning tube, R

The temperature in the tuning tube varies from one end to the other. The average temperature is determined by:

$$T_{avg} = \frac{T_1 + T_2 + T_3 + \dots + T_N}{N}$$

$$T_{avg} = \frac{845 + 705 + 610 + 580 + 580 + 575}{6} = \frac{3895}{6}$$

$$T_{avg} = 649 \text{ R}$$

and the apparent velocity of sound is:

$$V_R = 1292 \sqrt{\frac{460 + 385}{649}} = 1460$$

"Whiskers" Research

... may lead to remarkable new advances. Astounding strengths of filamentary crystals may be attained in bulk form.

Based on paper by **Arthur R. Lytle**
Union Carbide Metals Co.

CONTINUED current researches in the area of filamentary crystals or "whiskers" may lead to remarkable new advances. They may lead, among other things, to evolution of new approaches to fabrication techniques through which the astounding high strength of "whiskers" can be attained in bulk form. . . . And a real hope for the future is the possible exploitation of a new combination of properties in this branch of study that will present a practical challenge to the design engineer.

Promising researches in this important area of materials development have gained much momentum in recent years. Seven years ago the astonishing strength of filamentary crystals was already recognized. Since then these "whiskers" have been characterized as representing nearly perfect crystallization. They are generally free from dislocations . . . and also from the lattice defects responsible for the relatively limited strength of many conventional crystalline materials.

Presumably because of this freedom from usual defects, they possess almost theoretically perfect strength, in the order of 1,900,000 psi for iron, which is about 100 times the strength of ordinary iron crystals, for instance.

Such materials behave elastically up to their maximum strength, so, in appropriate applications, would presumably be useful to much higher than normal stress. Perforce the high elastic limits available in this sort of material is obtained with the exclusion of the usual plastic properties. This may inhibit the utilization of the high elastic strengths in many applications.

It is of considerable interest that in some basic solid state studies of graphite, methods have also been evolved for the production of graphite filamentary crystals. These have indicated tensile strengths on the order of 3,000,000 psi, a 1000 to 1 in-

crease over properties of normal graphite. The availability of these perfect crystals of graphite should broaden appreciably the research base in our studies to improve graphite properties.

In the intense desire of design engineers to employ materials having maximum strength/weight ratio, these findings on perfect crystals of metals and other materials have occasionally suggested the possibility that larger, massive structures could be processed to have these characteristics. It is now generally recognized, however, that bulk material having the properties of "whiskers" will be produced only by unconventional methods yet to be developed.

Nevertheless, some entirely new concepts have evolved recently, based on work that has shown that, in some cases the crystal structure of such strong whiskers is not as perfect as had previously been thought. This work, however, collaterally has indicated that some imperfect crystals have the unusual properties while others do not, hence, less obvious factors may play a part in the phenomenon of high strength. In spite of this uncertainty, the possibility that nearly theoretical strengths may be developed in bulk materials containing dislocations is an encouraging possibility.

The total research effort in this field of filamentary crystals is steadily increasing in intensity and breadth . . . probably because it portends fuller explanations of the basic problems of materials behavior. It may be able, for example, to answer such questions as: "Why do or do not materials support load up to a theoretical strength? How do materials fail? and so on.

These researches in filamentary crystals constitute an excellent example of the need for initiating and continuing research in the new and advanced areas of materials in order to develop an untrammelled perspective.

To Order Paper No. 56R . . .

... on which this article is based, turn to page 6.

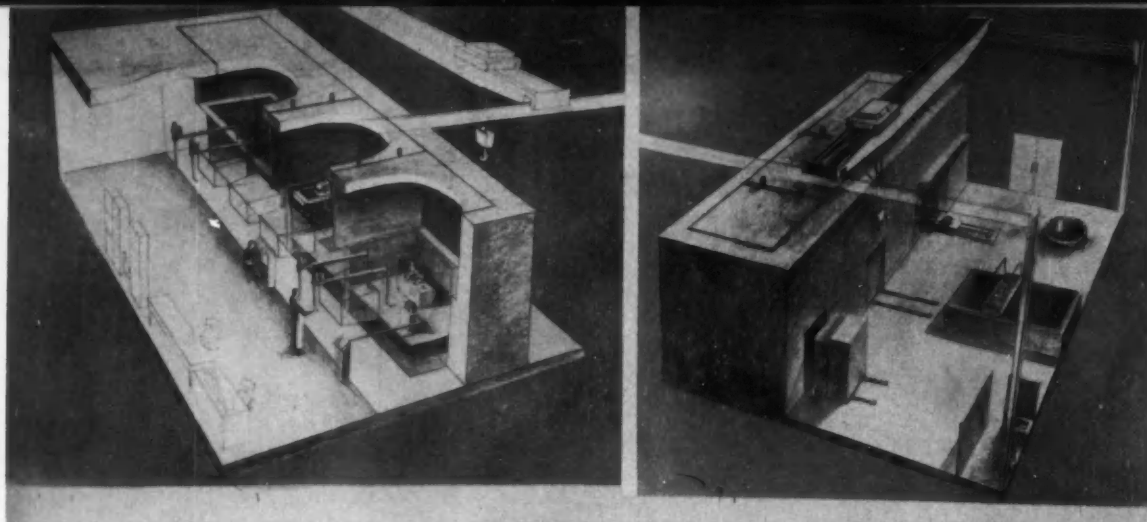


Fig. 1

Generalized concept of a hot lab (left) as viewed from the control room side; (right) from the service or hot side. Although not so depicted, roof slab of control room also doubles as equipment area to accommodate necessary heating and ventilating equipment. Other special types of equipment, such as high-frequency generators, can also be mounted in this area.

Location is readily accessible and easily serviced by means of overhead crane. Personnel access is by means of ladder located on opposite side of hot cells and within floor level service area. It is better, however to provide for access from control side, since personnel will not then have to walk over hot cell. (Sketch shows the less desirable method, since this laboratory was built into an existing facility, and there was no choice.)

Here are some tips on

How to Construct a "Hot" Laboratory

By

F. H. Ames, Jr.

Aircraft Nuclear Propulsion Department, General Electric Co.

CONSTRUCTION of a hot lab, such as the radioactive materials laboratory recently built by GE, presents special problems of materials, tolerances, and finish. Careful design, with particular attention paid to what may seem like insignificant details, and high-grade workmanship will, however, help to solve most of the problems and lead to the building of a lab that lives up to the design concepts.

Fig. 1 shows a generalized concept of a hot lab.

PRESENTED here are some suggestions for the construction of a hot laboratory where large amounts of radioactive material will be handled, such as an installation connected with a nuclear reactor.

They should not be construed as applying to laboratories using only small amounts of radioactive materials, as in tracer work.

Note the removable sliding walls separating the three cells. Alignment guides and the necessary tolerances required between the removable barrier and its guides can offer considerable trouble during construction. This condition may be especially aggravating if barrier walls and guides are of the same material—thereby contributing to the possibility of galling. Heavy and rigid members are needed to prevent bowing or other distortion. All sliding surfaces must be ground smooth and flat, with strict adherence to tolerances. Flatness of the removable barrier is important, to permit extraction of removable walls without binding between the wall and the guide slots.

The cells proper (Fig. 2) need to be reasonably airtight, to minimize ventilation difficulties. This requires strict adherence to tolerances in fabricating any removable roof slabs and may also necessitate calking around the edges of the slabs. If these slabs are keyed together and interlocked, it is advisable to paint the sequence-of-removal data on the slabs in addition to the identification for the individual slabs. Concrete slabs, such as those forming the cell overhead, can be held to proper tolerances while pouring the concrete by using heavy steel framing firmly anchored in place by rigid supports.

The two types of concrete cell access doors illustrated in Fig. 1 (right) are more or less typical of



those used for hot labs. The sliding door is easier to fabricate, since there are no changes in dimensions, which are necessary to give the stepped effect. On the other hand, the vault-type door is somewhat easier to put into place.

The doors must be fabricated accurately—especially the stepped or vault type. Although it may be a departure from normal construction practice, fabricating and pouring the door first and subsequently framing the opening will result in a more accurate fit.

The tracks of both types of doors should be smooth and level—with workmanship in the field most carefully checked. Sometimes an adequate groove is not provided in the floor to accommodate flanged wheels—and chipping hammers are such a nuisance in tearing out the interfering concrete!

The welds on the two water tanks (used for storage of irradiated materials within the service area) must be ground smooth and inspected carefully. Each tank must be calked to prevent decontamination liquids from seeping down into the sand pad. If the budget permits, use of stainless steel will minimize maintenance. Mild steel tanks, of course, require special painting or coatings.

Note that the rails shown for the access doors do not have any rail stops at the ends. This may seem like a petty detail, but experience has shown that, if such details are not properly shown on the drawings, considerable additional time and expense may be needed to get them taken care of during the construction phase.

shielding walls

There are several types of walls that will provide effective shielding—examples are ordinary concrete, heavy aggregate concrete, and walls filled with some type of metallic shot. All have one basic demand that *must* be met in order to prevent operational difficulties! These walls must be so erected in place as to assure uniform density; any voids, cracks or other "soft" spots are potential radiation hazards and must be avoided at all costs. Concrete of any type must be placed carefully and is best vibrated thoroughly in order to ensure uniform placement. This procedure is comparatively easy until we encounter those portions of the wall having inserts, openings, or penetrations. The mandatory shielding requirement for dog-leg or stepped type of penetration further complicates the problem since the possibility of voids becomes a probability if adequate precautions are not taken.

One solution to this problem is the use of a commercial process whereby all of the aggregate (usually a heavy type) is placed by hand so as to assure uniformity. Multiple tubes are maintained in a vertical position throughout the aggregate; grout is then forced in under pressure and, as the grout level rises, the tubes are withdrawn, to keep the open end a few inches below the level of the grout. This is a continuous process resulting in absence of joints or seams with careful placement of the aggregate practically ensuring uniform density.

Lead or steel shot can also be used to construct a wall of uniform density if placement is so done as to permit filling the areas beneath inserts, stepped windows, and the like. If vibrators are used, the walls should not be completely filled with shot and

vibrated, since this action could result in voids beneath any conduit, pipe, and so on, piercing the walls. This could be done, however, if there is some method of inserting shot into the void area after vibration, such as filling the wall to a point just below the pipe, and then hand ramming or compacting to eliminate voids or soft spots before proceeding with the filling process.

If possible, and this will seldom be the case, conduit and pipe routings should be made via the floor or overhead, to simplify shielding wall construction. This solution is usually impractical since space considerations or increased instrument lead length may cause undesirable complications.

Fig. 3 was taken during the erection of the steel forms for the shielding wall.

Since heavy-density shielding glass is soft, it is better that shielding windows be procured from the vendor complete with exterior protective glass and with the necessary steel framing for placement in the walls. Ordering the steel framing from the window vendor will result in a much better fit between the window and framing. Fabrication of the framing in the field would be more costly and time consuming because of the close tolerances required. The space between the window and the frame needs a high-density packing to minimize radiation penetration. Lead wool is fairly appropriate for this purpose.

Since some shielding windows are oil filled, be

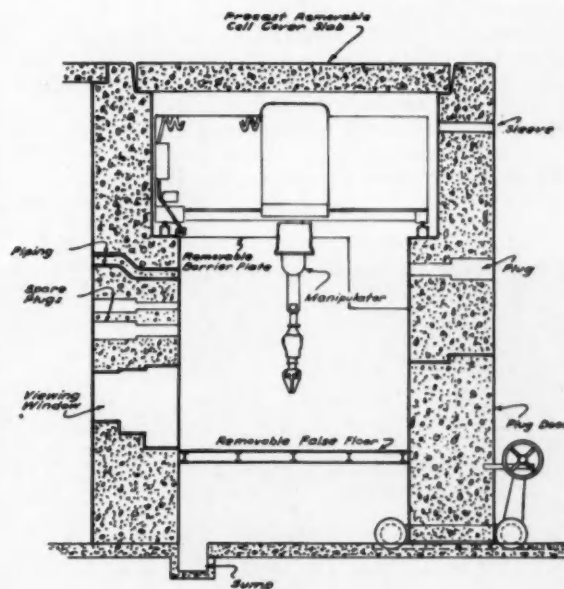


Fig. 2

Details of typical hot lab cell, showing, particularly, the shielding walls required for personnel protection.

extremely careful in making up the joints and use materials specified by the vendor.

The type of concrete wall shown in Fig. 3 will normally utilize metal forms that can be left in place to become the exposed surface of the cell walls after being filled. These forms must have an adequate number of tie-rods, to prevent springing. This requirement is lessened by the holding action of conduits, and the like, which are welded in position prior to placement of the shielding material itself.

finish

One of the basic requirements for a hot laboratory is a very smooth surface to minimize decontamination difficulties. The easiest way to smooth a metal wall is to grind it down—after first filling all pock marks in the metal—until a smooth surface is obtained. Incidentally, smoothness should not be confused with flatness. A layout block in a machine shop is both smooth and flat. In contrast, a hot cell wall must be smooth, but normally its flatness is of minor importance. A good method of testing after grinding, to determine that no snags remain, is to wad up a woman's nylon stocking and wipe the surfaces with it. If there is a rough spot, it will tear the stocking.

Other types of shielding walls may have a wood or metal strippable form so that a smooth final concrete finish is required after removal of the forms. This is not particularly difficult! Patching of all holes can be readily accomplished and should then be followed by grinding the entire wall in order to remove any objectionable protrusions.

Painting the concrete wall will undoubtedly be required after surfaces have been ground smooth. There are now numerous types of acceptable chemical-resistant paints and coatings on the market and such a covering will result in a smooth surface suitable for decontamination. In preparing the surface prior to painting and in applying these special coverings, it is most important that the manufacturer's recommendations be followed.

The two most common methods of surface preparation are etching by acid or by sand blasting. Etching will generally be the most desirable as sand blasting will produce considerable dust. This dust has a tendency to settle in the pores of the concrete, thereby preventing the best possible adhesion be-

tween the concrete and base coat of paint. The wall must be completely clean, dry, and dust-free for the proper application of paint—especially those special types which are used on surfaces subject to decontamination.

Many of these paint coatings are applied in thin multiple layers for best results. If an optimum amount is specified on a gallon per square foot basis, the painters *must* practice until they have mastered the technique of obtaining the correct thickness. Since any of these multiple layers will be potential trouble spots if not uniform in thickness, it is necessary to exercise great care during the entire application. One trick-of-the-trade is to vary the color of alternate coats or layers; by following this procedure any thin spots or holidays are readily detected by visual observation.

floors

If there is a drain in the hot cell, don't forget to put it in the lowest point of the floor! It is simple to design a floor with considerable pitch to the drain, but this may be undesirable because of complication in setting up test equipment within the cell; only sufficient drainage to assure removal of liquids should be specified. This will probably result in working and placing concrete to closer tolerances than normally required and it will be necessary to inspect carefully the details of floor construction.

The type of finish applied to the floor within a hot cell is somewhat of a controversy. Safety calls for a rough floor to prevent falls by personnel, but the health physics group demands a very smooth floor for ease in decontamination. As usual, a compromise is feasible. The floor can be finished smooth, painted, and individual abrasive pads cemented into place in those areas used by foot traffic. If there is a bad radioactive spill of material, the abrasive pads are ripped out, destroyed, and then replaced after decontamination has been completed.

Another possibility is to pour a thin topping layer of grout on the floor and cover this with large sheets of vinyl plastic, sealing the joints. If there is a very tough decontamination problem, the floor covering can be ripped off and the topping of grout chipped out; this will leave a "cold" floor base on which to rebuild.



Fig. 3

Photograph taken during erection of steel forms for shielding well. (Camera was located in hot cell itself.) The heavy steel wall plates, which form the exterior of shielding wall, have been welded into place and steel framing for right-hand viewing window is shown being welded into place.

Viewing windows must be handled very carefully during construction, especially if window does not have protective tempered glass exterior to soft shielding glass. Lead glass and other heavy-density glasses are extremely soft, so they must be carefully protected. Scratches can be removed by the construction force, but it is a time-consuming job.

Here Are Some

Lessons Learned from Comet Operation

Based on paper by **C. H. Jackson**

British Overseas Airways Corp.

IN retrospect, after 25,000 aircraft hours and 210-million revenue passenger-miles flown with the Comet 1, the circumstances halting temporarily the advance toward full benefit of jet transport seem to have been beneficial.

These circumstances led to the Comet 4 having a structure among the most rigidly tested and proved in the world, and to structural research and test methods that have set worldwide standards for new projects in relation to fatigue. And to these benefits can be added an acceptance of the need for more advanced methods of structural inspection routines, at least until operators have the full measure of the fail-safe and safe-life requirements that subsequently became prominent among standards for structural design.

lessons on instrumentation

Experience with Comet 1 indicated the trend of some future flight instrument requirements. Probably the most important of these related to the case for a take-off monitor, and to the need for better artificial horizons and better presentation of altimeter scales. Strangely enough it did not bring out the full implication of the problem of altimeter presentation, due perhaps to the limited scale of the operations.

Another revelation was the great significance of accurate fuel flowmeters and fuel gaging, not only to speed up transits but also to hold fuel loads to the level determined by flight operational requirements and not by doubts as to actual tank contents by weight. Fuel gaging is not very remote from navigation and some critical navigational requirements were foreseen and introduced because of the Comet 1, as for example, the need for DME and the likely ultimate need for lateral separation and track guidance; and the latter problem recently erupted into the arguments about Decca and DME(T).

duplication of auto-pilots

The speed of the jet and resultant concentration of crew duties is inclining us to the view that there is a case for two auto-pilots merely to reduce the likelihood of loss of an important operational aid. We also foresee the possibility that some operations

with large jet aircraft may need to be planned with less consideration to the availability of alternate airports, not because of fuel loads, but because of problems of strength of runways, overruns, taxiways, hard-standings, and so on. For this reason we are studying proposal for duplex and even triplex installations to provide auto-control down to flare-out so that scheduled transits can be used if even cross-wind or visibility conditions would indicate a preference for an alternate airport which, because of facilities and runway surface, would otherwise be undesirable. We do not expect, and will not need, to realize this conception until sometime late in the VC.10 and Boeing 707 era. But when we do, we'll be well on our way to obtain the full advantages of automatic landing.

Deterioration of engine power between overhaul periods leads to thoughts on the maintenance of power and on to thrust reversers. They are now being installed on the Comets, but the case for their installation is marginal. Even with this aircraft there are a few airports where the availability of thrust reverse will make the difference between a good and a poor commercial operation. In general, the advantages of installation seem well worth having for emergency conditions, for scheduling at critical airports, and to help reduce brake and tire wear on training flights involving accelerate-stop maneuvers.

choice of fuels

Comet 1 operation began on kerosene and nothing in our experience with Comet 1 or Britannia has caused us even to think of changing. The Comet 1 certainly introduced the problem of filter icing and this together with later Transport Command experience has led to the development of continuous fuel heating, which features Comet 4. We are satisfied with fuel company efforts to control cleanliness and initial water content, and with their continued work on the definition of test standards for fuel pumpability to measure and help remove any fuel "waxing" problems. We do anticipate a future series of detailed improvements and modifications to fuel systems and components to widen the margins by which we avoid any special operational procedure to cope with the "waxing" problem.

To Order Paper No. 62R ...

... on which this article is based, turn to page 6.

Planning Team Reduces Costs

Based on paper by

Harry D. Hall

General Motors Corp.

GM's Process Development Staff uses a Planning Team Activity to improve quality of product while reducing manufacturing costs. The team applies seven steps to the solution of any problem:

1. Determine problem or objective.
2. Study conditions.
3. Plan possible solutions.
4. Evaluate possible solutions.
5. Recommend action.
6. Followup to assure action.
7. Check results.

determining the objective

The supervisor of Methods Engineering and the supervisor of Process Engineering meet with divisional management for setting preliminary objectives, establishing the scope of the project, and deciding upon the specific area or activity to be analyzed. Care is taken that the area to be studied is self-contained, that is: changes in the chosen area to reduce costs will not result in equivalent or greater cost increases elsewhere.

At this meeting, plant management decides what divisional engineers will act as team members and work with a methods engineer and a process engineer from the Process Development Staff. Usually one of the divisional men is a methods engineer and the other a process engineer. However, in some projects one of the divisional team members has been from manufacturing supervision, or one of the staff functions directly involved with the area under consideration.

Once the original objectives have been established, all activities in connection with the project are closely watched to insure that team members do not deviate from the original objectives. As the team study work progresses, it is sometimes necessary to re-establish objectives. Thus, the objectives laid down at the initial conference are subject to revision.

studying conditions

The team studies existing conditions in the plant and records them. Photographs are taken of all operations and an act breakdown is made for each. Movies are taken where required, flow charts are prepared, plant layouts are made, and all other pertinent data, such as scrap reports, production schedules, and performance reports are gathered. Operation sequence possibility charts are prepared where necessary to determine to what extent the sequence of operations could be changed if it is deemed advisable.

It is important that the team study conditions as they actually exist. The team men maintain that there are three routings in each plant: the routing of record; the variation thought to exist by management; and the actual conditions on the factory floor. The use of photographs in this procedure provides an excellent means of communication.

Once the data has been collected, the team makes a careful review of the objectives originally established as well as the scope of the project. This frequently indicates there is need for additional information or it is learned the problems are not what they were thought to be at the outset of the project.

planning possible solutions

In studying conditions many problems are encountered. It is the team's objective to find solutions to these problems. In determining these solutions several alternates are considered ranging for example, from minor improvement of operator methods to complete mechanization. Frequently proposed solutions consist of suggested changes in product design, changes in plant layout, and revision to paper procedures within the plant. It is important that the team avoid a natural tendency to accept the first solution conceived. They must explore all possible solutions to determine which is best.

evaluating possible solutions

Once the possible solutions have been planned, the team proceeds to evaluate possible solutions. It is

usually necessary at this stage to call in other specialists. For example, on proposed product engineering changes, the product engineer is invited to review the proposed changes with the team. In some instances this results in the actual making of sample parts and may be as far reaching as to require field tests on the proposed parts.

Where changes in processing or tooling are considered, the tool engineer is consulted both from the standpoint of cost of the new tooling and the feasibility of the proposed change. This may also result in some physical work in that mockups may be built and tests conducted. Where these changes become long range and considerable time is required for experimental work, they are divorced from the team study and a separate project is initiated which can extend beyond the conclusion of the project at the division.

All of the proposed solutions to problems, of course, do not require physical changes and experimentation. For example: proposals that specific parts be manufactured rather than purchased are discussed with the Purchasing Department and the Master Mechanic's Section. This type of proposal can usually be resolved in short order. Proposed changes in paper work procedure, that is: the routing of reports and the need for reports, and action taken against reports, may require contact with accounting or production control as well as the Inspection Department.

The team establishes means of measuring such things as: improved quality, reduced lead time, and reduced parts in process, so that they can better evaluate some of the more intangible results of the study. In all cases, it is important that where reduced costs or savings are indicated in a particular proposed solution that we also obtain an estimate of the expenditures required to effect these savings. On each proposal sheet that is prepared, the savings and the investment are indicated. The effect of the team's efforts is very widespread within the plant organization when they are evaluating possible solutions, and the thinking of the entire organization is included. Naturally, there is not always agreement which is another reason for making trials and experiments.

In addition to labor, many of our savings are in material cost reduction, through more economical use of material, product design changes, or the use of substitute materials. Reduced inventory and floor space are also areas where savings are frequently possible.

recommending action

When the evaluation of possible solutions has been completed we proceed to recommended action. From the evaluation, a complete set of proposals is prepared. Each of these is individually recorded on large charts showing the old procedure, the proposed procedure, the savings to be gained, and the required investment. In some team study jobs these proposals have run as high as seventy-one in number. It is important in preparing these proposals that each stands on its own and that they are not grouped so that items which will not stand on their own ride along on the strength of others.

The results of the team study are reviewed by

the Process Development Staff management and changes, or additional studies, are made, if necessary. At this step, the team members have the opportunity to obtain additional ideas from the Process Development Staff management which takes advantage of the experience the management has had in shop problems.

All of the material gathered is then presented to divisional management. Since this is usually a fairly large group, the manner of presentation is important. The photographs, schematics, special charts and diagrams developed during the study of conditions are displayed as well as each of the proposals. All the material is explained and the proposals are presented. This job is usually split up so that each of the team members has a part of the presentation. By following this practice, the divisional men obtain valuable training in the presentation of material which will be helpful in future team studies carried on at the division without Process Development Staff assistance. The training the divisional members gain from participating in the team studies is one of the most valuable accomplishments of this work and it is expected these men will go on to train others in the divisional organization.

taking action on proposals

Taking action on the various proposals is the responsibility of the operating division, but Process Development stands ready to assist in any way possible. Frequently, at the presentation session the management divides the proposals into categories and assignments are made to specific individuals at that time. The divisional members of the Planning Team are in an excellent position to coordinate the installation of the proposals. Since they have worked on the entire problem, they have the necessary background and information to follow-up intelligently on all phases.

Logically much of this work becomes the responsibility of the process engineering personnel in the plant and the methods engineering personnel. Where other agencies are affected, they, of course, are given specific assignments. The plant management is naturally interested in executing first the proposals which show the highest return on investment.

checking results

To complete the picture we have the last step of checking results. This is done by the divisions and also by the Process Development Staff. The Process Development Staff requests each of the divisions to report within a few months following the presentation as to which proposals have been adopted, which presented difficulties, and what the overall result has been. Within the plant, the summary report provided serves as a good document for the management in following up on each of the proposals. A followup to date on team study jobs has proven very successful.

▲ To Order Paper No. 44R ...

... on which this article is based, turn to page 6.

Ford's extra heavy-duty

Based on paper by

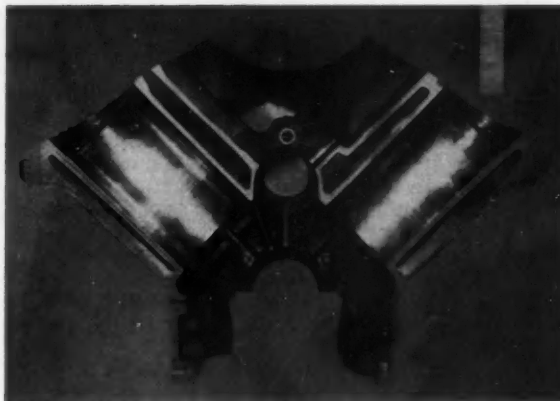
W. H. Gay and A. J. Tocco

Ford Motor Co.

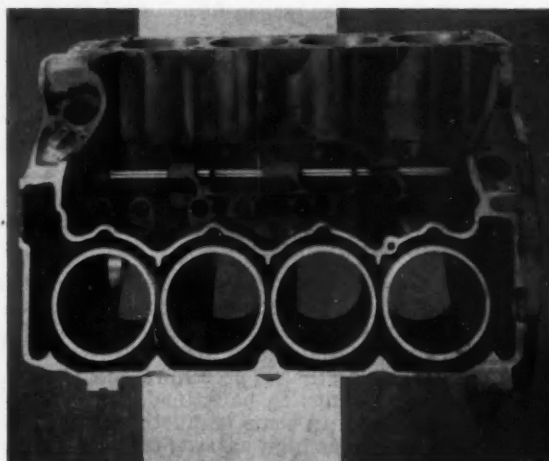
FORD'S extra heavy-duty truck engines were designed to furnish vehicles in the rapidly growing over-26,000-lb gvwt class with a powerplant giving better performance coupled with longer component life, less down-time, and greater economy. Short of components required to satisfy the different displacements, which run 534, 477, and 401 cu in., the line features almost 100% component interchangeability.

On this and the following pages are shown the salient features of the basic engine.

To Order Paper No. S156 . . .
on which this article is based, see p. 6.

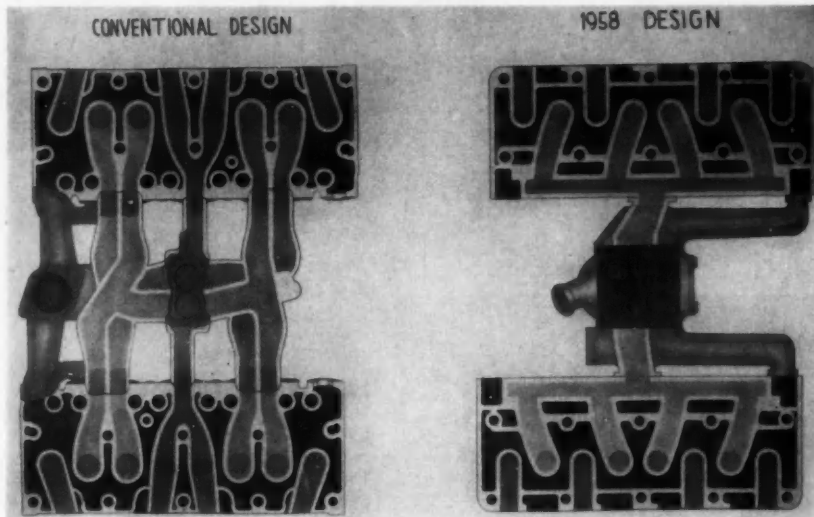


Cylindrical-wedge combustion chambers are formed by machining the block at a 13-deg angle with respect to cylinder bore centerline. Coupling this with a stepped piston top assures turbulence. All surfaces of the chamber are precision machined. Elimination of chambers in head simplifies head design and allows flat machining of all head faces. Almost perpendicular machining gives advantages in automated facilities and minimizes variations due to dimensional stackup.

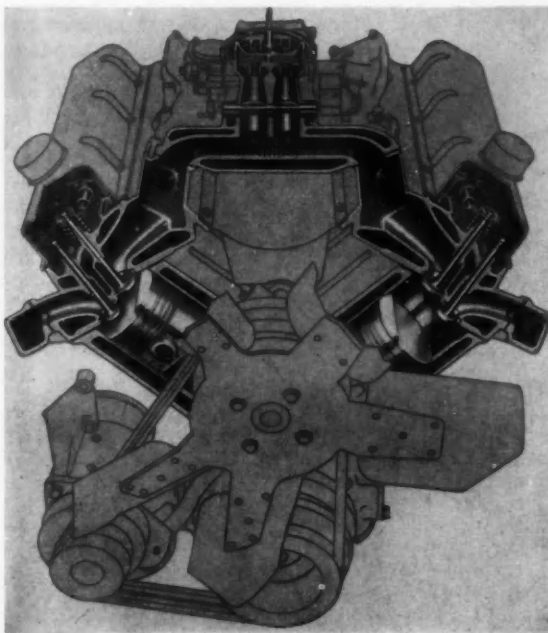


Serpentine wall construction design means that water-passage walls adhere closely to the contours of the cylinder bores. Deck rigidity is increased and less water is needed to cool the engine efficiently.

truck engines



Valve port arrangement is such that no two exhaust valves are adjacent to cause localized hot spots. Two intake valves are at the cylinder head center, with an exhaust valve at each end.



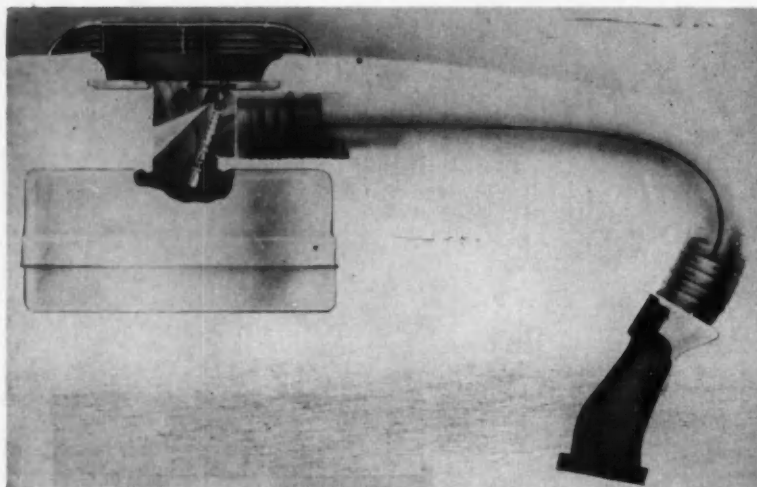
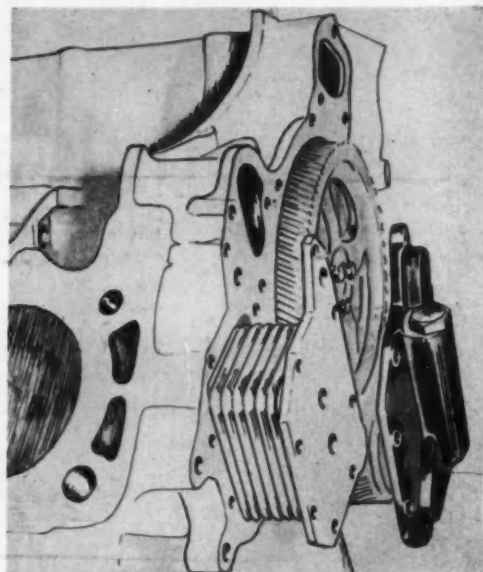
"Integral-type" induction system consists of two rake-type manifolds integrated with the cylinder heads, with a simple bridge between for the carburetor. Runners, normally incorporated in the intake manifold to conduct the fuel-air mixture to the cylinders, are eliminated, their function being handled by integral passages in each cylinder head. This design gives nearly unrestricted passage for fuel-air flow into each combustion chamber.

(continued on next page)

Ford's extra heavy-duty truck engines

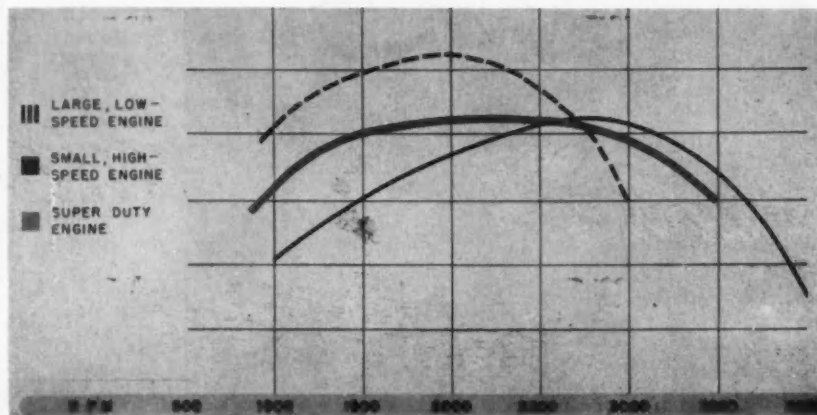
... continued

Conventional oil cooler is unconventionally mounted by insertion into the water passages at the right front face of block. No external connecting lines are needed and unit can be removed without major disassembling of components. Location allows 50% of waterpump discharge to scrub across plates for optimum heat transfer. During all tests, maximum oil temperatures in engine have not exceeded 250 F.



Hot and cold air induction system controls carburetor air temperature. Two air ducts are provided to the carburetor air cleaner assembly. One directs fresh air from an outside scoop; the other routes hot air from a scoop over the exhaust manifold. Both ducts juncture at the air cleaner, where mixture is regulated by a thermostatically controlled flapper valve. A thermostatic, vernatherm pellet, which actuates the flapper valve, is calibrated to maintain carburetor air temperatures at 80-100 F.

Torque curve satisfies conflicting requirements of a high top-end horsepower, limited maximum transmission torque capacity, and excellent low-speed torque. This particular shape of curve and the required net installed torque value were gained by the manifold and integral induction system design.



New Work on Aircraft Reliability Starts

A new SAE group is seeking to uncover and publicize "the right approach to reliability." First step is the pooling of industry's information on techniques.

"THE RIGHT APPROACH TO RELIABILITY" is the charge of a new SAE subcommittee. Both the Aircraft and Aircraft Powerplant Activity Committees are sponsoring the subcommittee in an effort to bring the best information to engineers in the missiles and aircraft industry.

Early Findings

Design, production, quality control, service, and maintenance departments—all must be actively aware of reliability, and working to improve it, the group agreed at its first meeting under Chairman F. D. Applegate, Convair. This attention to reliability applies to both suppliers and users. The problem is much like the "producibility" problem of 7-10 years ago. The problem faded when designers were made sufficiently aware of "producibility." Perhaps the reliability problem can likewise be lessened by emphasizing to designers the importance of "reliable" design details.

Users must help designers by furnishing accurate information on the environment implied by the mission and also the transportation shocks and the wear and tear of servicing and maintenance. The man with the screwdriver is part of the "environment" too, and he may be a raw recruit rather than a skilled technician, committeemen observed.

A realistic definition of reliability is needed at the start for any product under consideration. "The probability of the equipment's performing its assigned tasks" is about as good a brief, overall definition as any, the committee concluded at its first meeting.

One way to report reliability is in terms of mean time between failures. That's the total number of successful hours flown divided by the number of failures causing a mission to abort. Scheduled removals don't count, and neither do failures that don't result in aborting the mission. However, such failures may count against maintainability ratings. Statistical reliability data can be mishandled,

committeemen noted. Too often, people calculating reliability treat their data as if failures were due to random errors. Failures may not be random; they may stem from a common source. The statistician must cull his data and exclude data not suited to statistical analysis. A time plot of failures often gives an indication of their randomness.

In the case of complex equipment, reliability can be demonstrated by determining the areas of minimum functional capability and concentrating tests on those places or parts.

Qualification tests might possibly be expanded to help demonstrate reliability, it was pointed out. Perhaps a lesson can be learned from the people who design experiments for the U. S. Department of Agriculture. There are often 40-50 factors in the success of a particular crop. A test program which varied one factor and held the rest constant would require too many seasons or too much land to complete. But, in properly designed experiments, it's possible to vary many factors at once and still get valid results. Qualification-test programs planned on the same principle might satisfy the military and still not be exorbitant in cost or time.

Those named to the subcommittee by the time of its meeting on January 14 were:

F. Daniel Applegate, Convair (chairman)
Frank A. Alonso, Lockheed
Neil Bergman, Rocketdyne
W. S. Broffitt, Allison
David Krause, Convair
R. E. Ledbetter, General Electric
R. H. Loughran, Hughes Aircraft
Justin Neuhoff, General Electric
Herbert Rawdon, Beech
Donald L. Meehan, Douglas
R. F. Stapells, Canadair
Harold W. Zipp, Boeing

Chairman Applegate intends to add others to the subcommittee by the time of its next meeting on April 1, in New York City.

Ramjets can be smaller with pyrophoric fuels

Based on paper by **M. C. Hardin and F. J. Verkamp**
Allison Division, CMC

PYROPHORIC fuels — which ignite spontaneously upon contact with the air — appear to offer promise of smaller, lighter ramjets for target drones. They may also simplify ignition of turbojet burners and afterburners.

The accompanying table presents the physical and chemical properties of the three pyrophorics considered most promising, because of physical properties, availability, and other considerations: trimethyl aluminum (TMA), triethyl aluminum (TEA), triethyl boron (TEB).

These colorless liquids exhibit good storage stability below 200 F and are compatible with most basic metals of construction. However, Kel-F or Teflon must be substituted for rubber seals.

The net heating value of the alkyl aluminum compounds offers no advantage and the TEB a relatively small advantage over hydrocarbon fuels. Their densities approximate those of analogous hydrocarbon fuels. They are indicated to have acceptable thermal stability based upon studies to date.

The alkyl boranes have one inherent advantage over the aluminum counterparts in that they are relatively nonreactive with water, whereas the alkyl aluminum compounds react with explosive violence to liberate large volumes of light hydrocarbons and hydrogen.

Another inherent characteristic of these pyrophorics is their apparent high reaction rate with oxygen at low temperatures and pressures. Based upon comparative tests, TMA appears to be the most reactive, with TEA and TEB each a rather poor second. Data pertaining to TEA and TEB are not consistent in relative ranking of the two.

The limited liquid range and high freezing point of TMA seriously limit its application as a military aircraft fuel. TEA is also at some disadvantage in this regard as a freezing point below -76 F is normally desired. Hence, mixtures of TMA and TEA were investigated in regard to their freezing points and reaction rates. Properties of a 25% TMA/75% TEA mixture are presented. Mixtures of the two materials have eutectic characteristics as shown by the incomplete phase diagram at the right. This characteristic permits consideration of a low freezing mixture having improved reaction rates over TEA. These materials form considerable amounts

**Physical and Chemical Properties
of Pyrophoric Fuels**

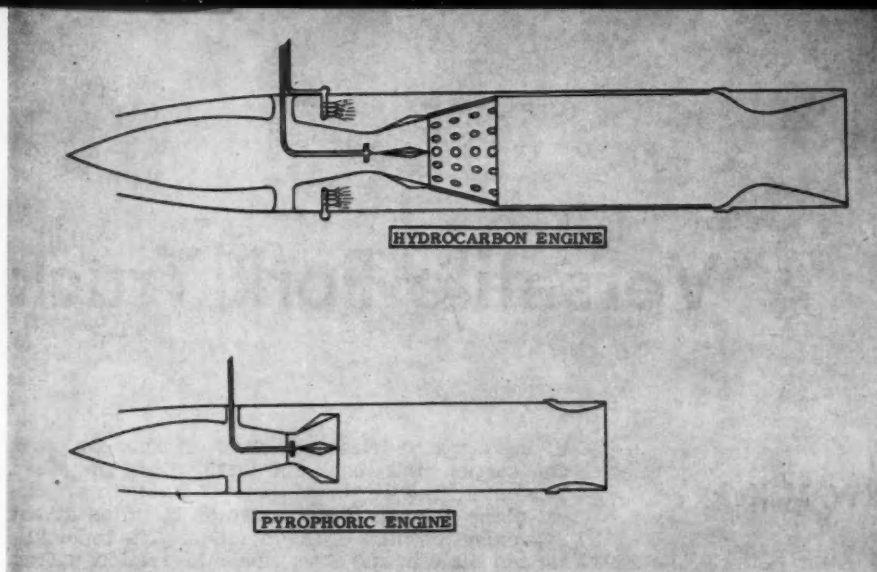
	Trimethyl Aluminum (TMA) — (CH ₃) ₃ Al	Triethyl Aluminum (TEA) — (C ₂ H ₅) ₃ Al	Triethyl Boron (TEB) — (C ₂ H ₅) ₃ B	25% TMA + 75% TEA
Boiling Point, F	258	367	203	335
Freezing Point, F	59	-53	-134	-75
Net Heating Value, Btu/lb Btu/gal	17,820 112,000	18,300 128,000	20,300 116,000	18,170 124,000
Density at 77 F	0.75	0.84	0.688	0.82
Hydrolytic Stability	Reacts violently	Reacts violently	Does not react	Reacts violently
Lb Metallic Oxide per Lb Fuel	0.708	0.450	0.357	0.510
Combustion Oxide	Al ₂ O ₃	Al ₂ O ₃	B ₂ O ₃	Al ₂ O ₃
Oxide Melting Temperature, F	3710	3710	940	3710
Thermal Stability	Thermally stable to ~ 300 F	Thermally stable to ~ 300 F	Thermally stable to ~ 200 F	Mix will separate at ~ 350 F
Stoich. F/A Ratio	0.088	0.0790	0.0678	0.0813

of nongaseous combustion products. Ideally, 0.708 lb of Al₂O₃, having a literature melting point of 3710 F, would result from the burning of 1 lb of TMA. With TEA, the value is 0.45 lb per lb of fuel. The oxidation of TEB ideally produces 0.357 lb per lb of boric oxide (B₂O₃), which has a literature melting point of 940 F, and a wide liquid range.

Present prices for these materials range from \$5 to \$20 per lb, when commercially purchased in quantities needed for experimental work. However, price estimates for these products range to 25¢ per lb in the near future, when commercial demand becomes sufficiently large to justify their large-scale production and marketing.

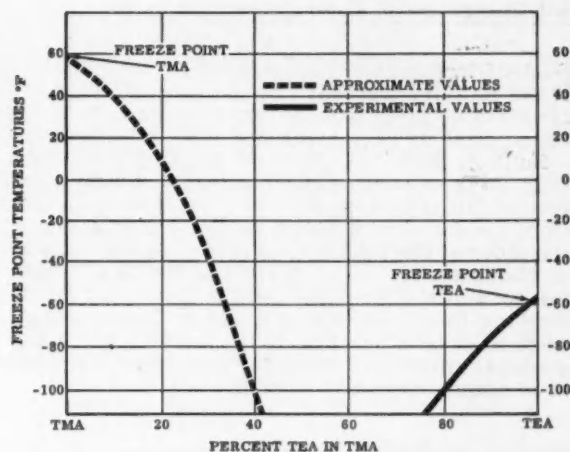
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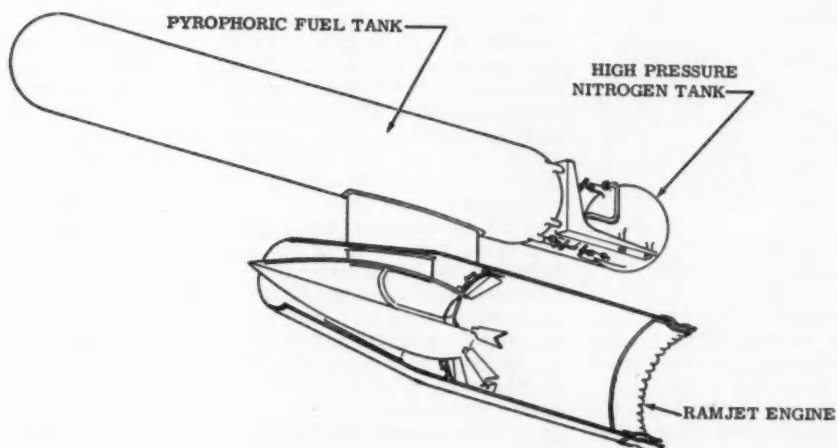


Schematic diagram of ramjet engine system using pyrophoric fuel. Note prepackaged fuel tank and system, which is readily replaceable. This avoids fuel transfers and the necessity for extensive purging equipment and procedures in the field.

The system would be filled at a central source and sealed by means of rupture diaphragms. The fuel tank, fuel controls, and possibly the complete injection system would be shipped in this condition under small inert gas pressurization. To use, the package would be mounted on the engine and the nitrogen pressurization tank attached. Means can be devised so that the fuel seals are automatically ruptured during assembly, thereby arming the system. By this means, field personnel hazards would be minimized and little supporting field equipment required.



Approximate phase diagram of triethyl aluminum and tri-methyl aluminum blends, showing eutectic characteristics of mixtures of the two materials.



Versatile Fork Truck

Based on papers by

**Jerome R. Susag, Dale W. McKee,
and Cyril B. Rogers**

Clark Equipment Co.

Abridgment of an

SAE Chicago Section (South Bend Division) paper

CLARK Equipment has developed a fork lift truck for military use that has the unique feature of maintaining forks parallel during all phases of the lifting cycle by means of a hydraulic cylinder.

Built in 6000-, 10,000-, and 15,000-lb load sizes (Fig. 1), these vehicles can pick their load from the ground, lift it 12 ft in the air, place it or remove it from the far side of a flat car, side shift the load the width of the machine, tilt it from 45 deg forward to 30 deg aft, and rotate it right or left 10 deg from the horizontal. They meet requirements calling for carrying their loads through salt water up to 5 ft deep, over sand beaches, rough terrain, up 45-deg grades at minimum 2-mph speed, and over highways at minimum speeds of 15 mph.

overall hydraulic system

The hydraulic system controls five separate motions of the lifting forks and three modes of steering — front wheel steer, 4-wheel radiarc steer, and 4-wheel oblique steering. It also supplies pressures for operation of the torque converter, and manipulation of clutches in the transmission, which are used for shifting from forward to reverse and from low to high speed.

Three pumps supply the necessary pressures. A main pump powers the five fork motions, a smaller pump handles steering, and another smaller pump supplies the torque converter and transmission. These pumps are coupled directly to the engine so that hydraulic fluid flows through the systems whenever the engine is running, whether pumps are working or not.

control of lift fork motions

The forks mounted at the end of the arm-type lifting mechanism are raised or lowered by means of two double-acting lift cylinders, trunnion mounted to the truck frame, with the rod ends attached to the lifting arms. Extension and retraction of the forks are accomplished by designing the

lifting arms to telescope. Two sections are used. One section slides back and forth within the other. The outer, heavier "boom section" pivots in a vertical plane above a heavy trunnion mounted at the approximate center of the machine. The innerslide section slides in and out of the outer section, carries the forks at the outer end and is coupled mechanically at the inner end to the outer section by a double-acting "extension" cylinder.

A tilt cylinder on the innerslide tilts the forks forward or rearward. Slide shift of forks is accomplished by mounting them on rollers which traverse the channels on the fork carriage. The drive is by means of a double-acting "side shift" cylinder.

Provision for picking up a load that might be canted up to 10 deg with respect to the truck was accomplished by designing to cant the entire truck rather than just the forks. Both front and rear axles are trunnion mounted to the truck frame by means of rotating cradles (usual practice is to mount only the rear axle on such a cradle). Consequently, the entire truck is capable of rotating 10 deg with respect to the axles and the ground. A double-acting cylinder is mounted at the front axle out near the wheel and links the frame side member with the axle end. In mid-stroke the cylinder holds the truck level. When this cylinder is extended or retracted it causes the truck to rotate to left or right.

keeping forks parallel

Trucks of this general type usually employ the so-called "parallelogram" type of lift arm configuration. However, the requirement for reach or extension in this design made the parallelogram design impractical. It was decided instead to use a hydraulic compensating device that would automatically cause the necessary amount of fluid to be displaced in the tilt cylinder, so that the forks would not change their tilt angle while being lowered or raised unless the operator wished.

To accomplish this function, some type of fluid pump was required that would be driven by the up and down movement of the lifting arms, so that the displaced oil in the tilt cylinder would correlate with the rate and amount of lift. Lift arm angularity with respect to the truck axis, also entered the problem. It was decided to use a "slave" cylinder to perform this pump function. This cylinder is mounted so that its base is coupled to the truck frame while the rod end is coupled to a bell-crank or short arm welded rigidly to the pivot end of the

for Military Use



Fig. 1 — Clark military fork lift truck has unique hydraulic device, which automatically keeps the forks parallel while lifting. It has five distinct lifting motions and three modes of steering.

lift arms. With this arrangement the slave cylinder is caused to collapse when the lift mechanism is driven upward by the lift cylinder and, conversely, to extend when the lift mechanism is driven downward. The correct amount of fluid displacement is controlled by design of the stroke and cylinder diameter of the slave.

The two cylinder lines from this double-acting slave cylinder are teed into the two tilt cylinder lines, rod-end to rod-end and base-end to base-end, so that the difference in displacement between rod-end and base-end would cause no difficulty. The tilt cylinder is caused to lengthen or shorten itself automatically during the lift movement by the fluid displaced by the slave cylinder.

difficulties and their cure

The circuits between the slave and tilt cylinders are closed when the operator is not manipulating the tilt control, inasmuch as the two tilt cylinder lines going into the control valve are then dead-ended at the valve. This could cause trouble during certain unusual lift conditions. If the operator, for instance, began the lift with forks tilted forward to the limit, the slave cylinder would continue to try

to force fluid into the tilt cylinder in a direction to cause further forward tilt. But inasmuch as the tilt cylinder is at the limit of its stroke it could no longer receive the fluid arriving. This would cause two intolerable conditions. First, the line carrying the fluid would burst, or serious damage would occur to the structural linkage. Second, the other end of the slave cylinder would commence to draw a vacuum. The same condition would occur in reverse.

This problem was solved by inserting an auxiliary relief valve and a check valve in each of the two lines. The relief valve is set to open at a pressure slightly in excess of the normal setting and when it opens it diverts the excess fluid back to the reservoir, but allows no flow in the opposite direction. The check valve, inserted in the circuit parallel to the auxiliary relief valve, allows no flow out of the cylinders but will open at a very low pressure differential to allow flow from the reservoir into the cylinders if the system commences to draw a vacuum. With the addition of these valves in the circuit, the system functions satisfactorily under any operating condition.

To Order Paper No. S172 . . .

... on which this article is based, turn to page 6.

Passenger loading and baggage

Obstacles

Based on paper by

J. F. Horan

Boeing Airplane Co.

JET transports are revolutionizing air travel, but the full impact will not be realized until terminals are modernized, especially to banish the bottle-necks of passenger loading and baggage handling.

Towing jets to and from loading gates is under consideration in airport layout planning. The reasons for towing as sometimes cited are jet exhaust noise and velocity, fuel consumption during taxiing, increase engine running time, and the possibility of ingesting foreign objects. But towing with available equipment is not practical at speeds approaching normal taxi speeds.

solutions to towing problem

Wheel moving vehicles are being proposed to replace tow trucks between the terminal and some starting point near the runway. These vehicles, originally developed for moving heavy Air Force airplanes in Arctic regions, use part of the airplane's weight to develop traction. The scheme has worked well with tandem-type landing gears and is now being developed for tricycle-type gears. Aside from high horsepower requirements for long distance towing at speeds approaching taxi speeds, auxiliary electrical power and cabin air-conditioning must be available from the vehicle when passengers are aboard.

The ultimate tow tug must be a practical lightweight vehicle, using airplane weight for tractive effort, with quick coupling and pilot control features so that the airplane can be moved safely at taxi speeds. Such a vehicle could be used to move the airplane from the passenger-loading area to the take-off runway.

A schematic diagram of four types of mover ve-

hicles either proposed or under development is shown in Fig. 1. Two types couple to a main landing gear. A third type attaches to the wheels of the main gear, while a fourth type is a self-propelled vehicle which obtains its tractive effort by transference of a portion of the airplane weight at each main gear.

Both noise and jet exhaust effects in the passenger loading area can be reduced greatly by a straight taxi into the loading gate, and a push out rearward from the gate to a remote position where the engines may be started and the airplane taxied to the runway. Passengers could enter or leave the airplane at the second-story level through a fixed gate at the forward door, and an extendable bridge at the rear door.

staggering problem of baggage

Unless methods of handling baggage are improved so that the passenger gets his baggage with a minimum delay, some of the advantages of jet travel will be lost. This speed of handling is more important to domestic than overseas operators.

A preloaded container system has been developed which is now being used on certain Boeing 707 models. Containers contoured to fit the shape of the cargo compartment, each capable of holding 36-40 bags are loaded and transported to the airplane on special dollies. A loader lifts the container to the cargo compartment deck level from whence it is moved fore and aft in the compartment on a built-in, mechanized conveyor system. Six containers in the forward compartment can handle all passenger baggage, leaving the rear compartment free for freight. Fig. 2 shows how this system could be integrated into terminal operations to get maximum advantage from it.

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handling are . . .

to Full Jet Utilization

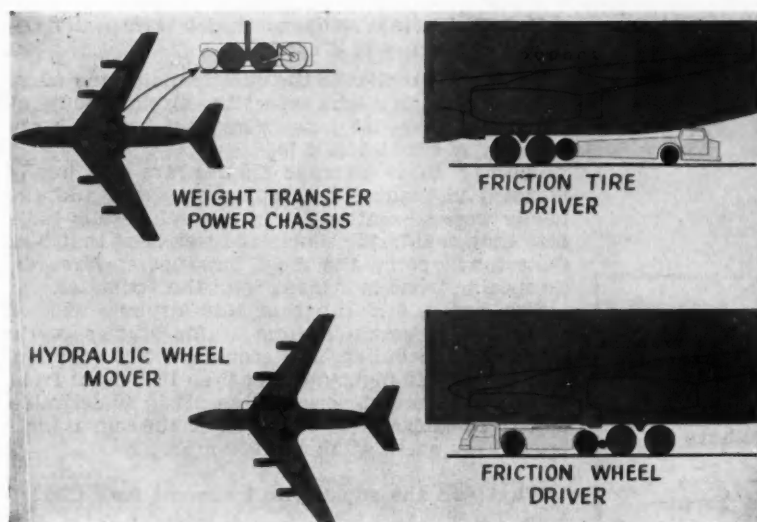
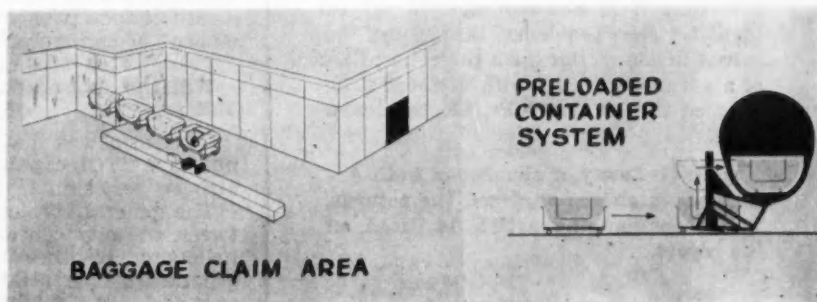


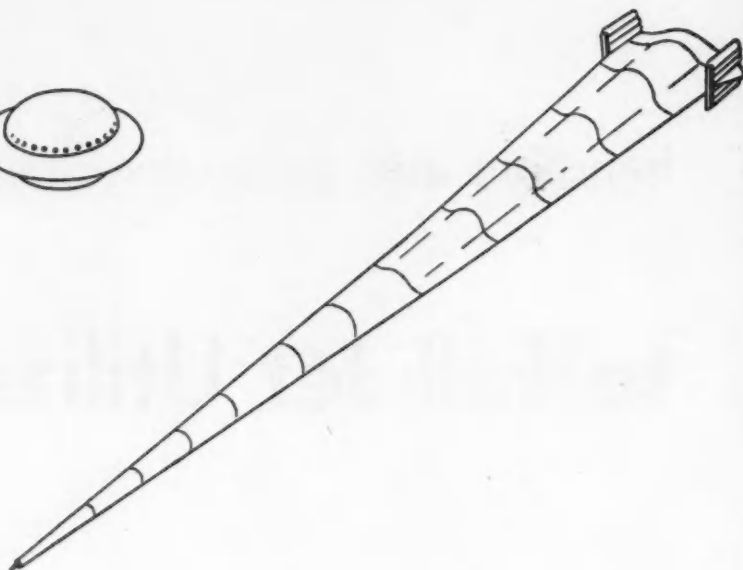
Fig. 1—Four types of mover vehicles proposed or under development. (Right) two types couple to a main landing gear, one rotates the airplane wheel with a roller, the other with drive wheels. The driving members of both are pressed hydraulically against the airplane tires. Tractive effort is furnished by weight of the airplane; motive force is provided through the tire friction drive. (Lower left) a device attaches to the wheels of the main gear, usually used in pairs, one to each main gear. Each unit has two hydraulic motors in the gear train which apply power to ring gears installed permanently on the airplane wheels. A power unit vehicle furnishes hydraulic power for the wheel mover set. The power unit attaches to it and is towed by the airplane. (Upper left) a low silhouette vehicle obtains its tractive effort by transferring a portion of the airplane weight at each main gear to the vehicle. The vehicle provides the motive force.

Fig. 2—Baggage handling method used on some Boeing 707 transports. Containers contoured to fit cargo compartment are preloaded with baggage, carried on dollies, and lifted by loader into compartment, where they are moved fore and aft by a built-in conveyor system.



Here are some ideas on what the

Supersonic Transport of 1975



may look like

Based on a report by **John G. Lowry**
National Aeronautics & Space Administration

“What will the supersonic jet transport airplane of 1975 be like?”
“What are the problems involved in building this transport and putting it into service, and how soon do we have to solve them?”

These questions the SAE Air Transport and SAE Aircraft Activity Committees asked themselves some months ago in questionnaires. The purpose was to get people thinking about the problems of the future—not, of course, to produce a serious study. Committeemen feel that it is not too soon to try to identify the problems that must be solved in connection with the generation of air transports that will, by about 1975, succeed the DC-8's, 707's, Electra's, and 880's.

John G. Lowry, a member of both Activity Committees analyzed the returns. The accompanying article is based on his report.

How fast will the supersonic jet transport fly—and how much will it carry?

Taking the replies to the questionnaire and averaging them, one might expect the airplane to fly at Mach 2.1, carry 135 passengers, and have a cargo capacity of about 12,500 lb.

Perhaps these average figures are not really meaningful because the replies on speed and capacity were so scattered. In general, results indicate that in 1975 the supersonic transport that flies fastest will carry the most passengers; however, no specific trend is evident from the estimates.

Size, speed, and range of this airplane will, of course, be determined from traffic studies, route structure, scheduling, and economy. For example, very high speed flight (greater than 1000 mph) from east to west might very well result in undesirable departure and arrival times, since the sun travels around the earth at about 1000 mph.

What will the supersonic transport look like?

The few answers received indicate that it will have a triangular planform. One respondent suggested that it would look something like the B-58.

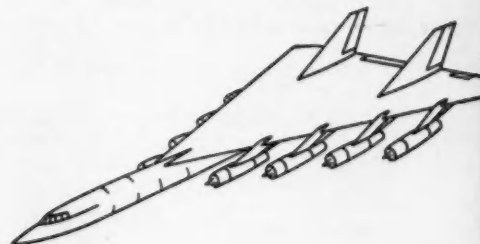
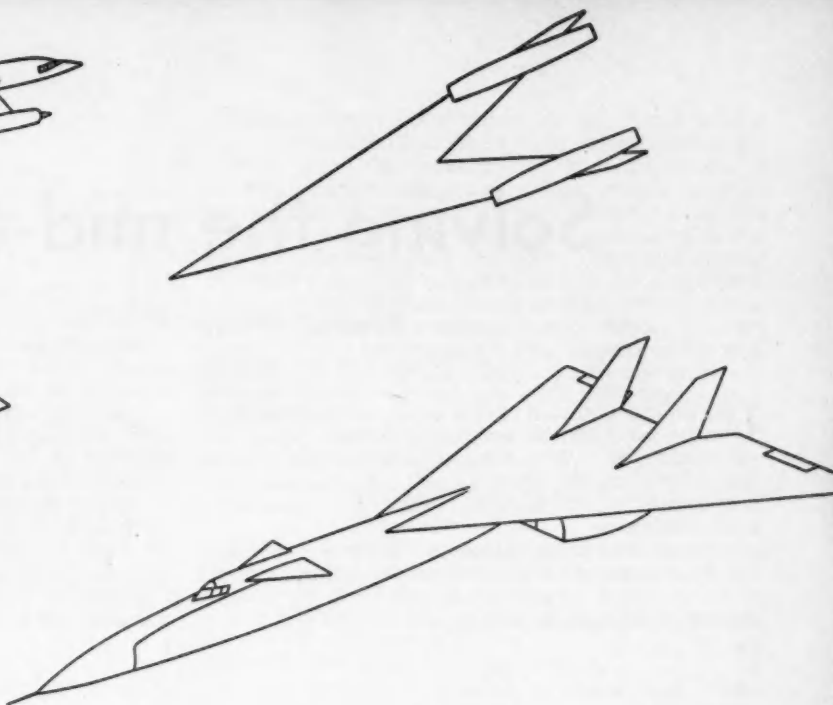
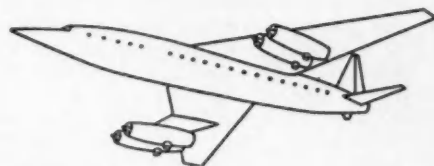
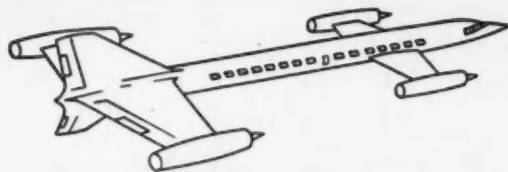
To give some idea of what others are thinking about in the way of configurations, the sketches shown here were prepared from published papers.

As far as the Committees' survey, it looks as if it's a case of “you pays your money and you takes your choice” of configuration.

Will the supersonic transport have VTOL capabilities?

Consensus was that the supersonic transport will *not* have VTOL capabilities, but it will operate from airports very similar in location to our present ones.

The general opinion was that transportation between the city centers and the airport will be by helicopters or other VTOL aircraft. A few felt that ground transportation would continue to be important and that it might be of the monorail type.



What are the major technical problem areas?

The major technical areas (those most frequently mentioned in the questionnaire) were:

- Air traffic control, which included such things as instruments and devices for navigation, collision avoidance, blind landings, and automatic take-offs and landings.
- Noise, which includes jet engine noise suppression, sonic boom, and boundary layer noise.
- High-lift devices, or improved landing and take-off performance, and STOL configurations.
- Powerplant optimization, particularly non-afterburning.
- Satisfactory airports and ground handling facilities.

A more complete list of the problem areas is given in Table 1. Chronologically, the results indicated that between 1960 and 1965 a solution was needed to the operational problems of the supersonic transport. This, in general, includes air traffic control and instrumentation. It is felt that the early date results probably because the solution can be applied immediately to the current jet transports. By 1965 it was felt that a survey of the markets, route structures, and schedules would have to be made to know what was needed in the way of a supersonic transport. The latest date that the configuration can be clarified is 1970. This includes engines and engine installation, structures (high temperature), high-lift devices, and so forth. In addition, we need a clarification of what precautions are necessary for safely transporting passengers on a scheduled basis at 70,000-ft altitude, which will include such things as rapid descent without discomfort to passengers, cosmic radiation, and inadvertent decompression. By 1973 satisfactory airports and ground handling facilities for servicing including the handling of high energy fuels, passengers, and baggage should be available, and we might add, satisfactory transportation to city centers.

Table 1 — Major Technical Problem Areas

Problem	Solved by
Air traffic control	1965
"Black boxes" (instruments and devices for navigation, collision avoidance, blind landing, automatic take-off and landing, etc)	1965
Noise (suppression, sonic boom, etc)	1970
High-lift devices and improved landing and take-off performance	1970
Powerplant optimization	1970
High-temperatures problems (structure, fuel tanks, cabin, etc)	1970
Satisfactory airports and ground handling facilities	1973
Configuration (including stability and control)	1970
Improved cruise drag (L/D and BLC)	1970
Determination of requirements imposed by market and schedule considerations	1965
Improved structural materials	1970
Development of suitable fuels and fuel systems	1970
Ability to carry passengers at 70,000 ft	1970
Improved ground transportation	1970

Solving the mid-air collision

Based on paper by **Frank C. White**

Air Transport Association of America

THE prospects for an operationally acceptable, self-sufficient collision avoidance system (CAS) are practically nil. Why this is so has nothing to do with cost or weight of equipment; the reasons relate specifically to fundamental physics of motion of bodies in space.

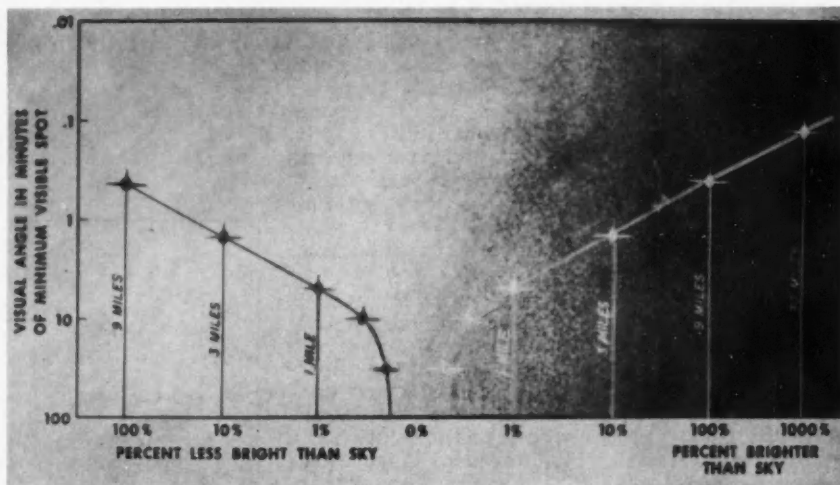
On the other hand, the prospects for a cooperative CAS are good. In such a system an aircraft would have to carry a cooperative "beacon" for a fully equipped aircraft to detect and so avoid collision.

Many systems have been proposed and several are under active investigation, though the only Government funded program at this time is the Federal Aviation Agency program with Bendix Radio.

The long lead time required for the development and installation of a cooperative airborne system has led to the demand for a "less-than-perfect" system which results in the requirement for a self-sufficient, proximity warning indicator (PWI). The purpose of a PWI is to alert a pilot to the presence of other nearby aircraft and advise him in what direction to look for them.

Currently, there are two self-sufficient PWI developmental areas. These are the PWI attachment

What's the matter with pilots? Don't they scan



Courtesy, "Flying Safety"

Fig. 1—Pilot of a small jet aircraft having a 10-ft fuselage will have one minute of visual angle at about 7 miles, but the visual angle will vary with variation in contrast.

HUMAN VISION has certain weaknesses which make it unreliable as a collision warning device, according to Dr. Walter F. Grether of the ARDC Aero Medical Laboratory. Here's the way he explains it:

The larger the airplane, the further away you can see it. For an aircraft to be visible, its angular size (visual angle) must exceed the threshold angle for visual acuity and that angle is about one minute of arc. A small jet aircraft with a 10-ft fuselage will give a pilot one minute of visual angle at about 7 miles, but only when the following conditions are

met: (a) daylight lighting; (b) there is a high brightness contrast between the aircraft and the background (sky, clouds, or earth); the pilot's eyes are focused for distant vision; and (d) the pilot is looking directly at the other aircraft.

There is little one can do about Item (a). Item (b) might be affected in some instances by better aircraft painting or lighting. The variation of the visual angle with variation in contrast (Item d) is shown in Fig. 1.

Dr. Grether suggests that the pilot's scanning

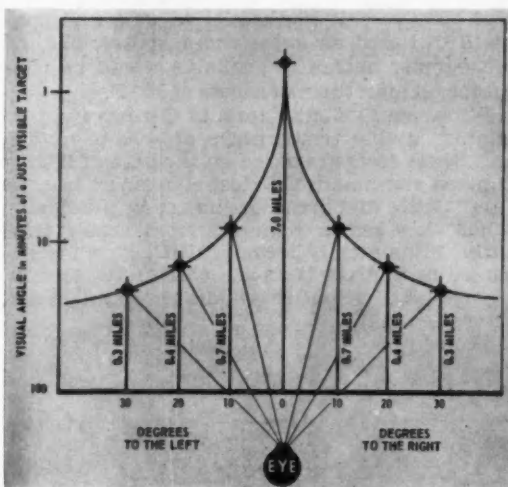
problem

to an airborne radar and the use of an infrared system.

Proximity warning indicator

The military (MATS and SAC) have been investigating the use of a proximity warning attachment to an airborne radar for some time. Once airborne radar is installed for other reasons, it is logical to consider the practicability of utilizing it for a proximity warning indicator. RCA made the first detailed public proposal for a PWI attachment to a weather radar and an experimental version is being flight tested by an airline.

the sky carefully?



Courtesy, "Flying Safety"

Fig. 2—Need to cue pilots is shown by the effect of offset viewing angle on detection distance for fighter size aircraft.

habits might have some effect on Items (c) and (d). His plot of the effect of offset viewing angle (Fig. 2), should convince even the most skeptical that human vision can be aided considerably by "cueing" the pilot where to look. Flight tests conducted by the Technical Development Center of CAA indicate that, on an average, human vision can be improved by a factor of three to one if the pilot is advised where to look. Such an improvement, if attainable, is worth working for.

Since ground clutter will render the radar useless at ranges greater than the aircraft height above the terrain, the PWI attachment should provide a method of automatic range gating to eliminate all signals beyond the range. Furthermore, since the airborne radar PPI display is of marginal value for PWI purposes, the PWI attachment desirably should generate a separate suitable display. If direct view storage tubes are provided for cockpit display of the airborne radar, the supplementary display of PWI data may not be required. PWI display could well provide the stimulus needed to "push" the more expensive direct view storage tube PPI display into cockpits.

Advantages and disadvantages

The PWI attachment has two advantages. These are:

- Light weight. Assuming airborne radar has been provided, the attachment itself should not weigh over 25-30 lb.

- Only minor modifications of the airframe are needed for installation.

The disadvantages may be listed as:

- Coverage limited to about ± 5 deg of flight plane and forward 180 deg sector only (assuming radar antenna is mounted in aircraft nose and antenna tilt is set to 0 deg).

- Weather clutter will reduce effectiveness by causing false alarms.

- Maximum range is limited by height of aircraft over terrain.

Infrared PWI system

Several proposals for infrared PWI systems have been generated. The Aerojet-General system awaits a decision by the Government to fund a measurement program, having pointed out that not enough is known about the infrared signature of light planes to permit the design and construction of a successful infrared PWI system.

Raytheon is continuing its efforts to use propeller modulation as a specific infrared signature to eliminate the problem of jamming from the direct or reflected energy of the sun. Minneapolis-Honeywell's proposal includes the use of somewhat revolutionary infrared technique which cannot be discussed at this time.

Advantages and disadvantages

Infrared systems have the advantage of light weight (unless detector cooling is required; breakthrough in state-of-art could reduce complexity and weight of detector cooling). They also have excellent relative bearing measurement capability.

The disadvantages are four in number. They are:

- False indication on "hot" ground sources unless system design prevents it.

- Jamming from direct or reflected energy from the sun, or both, unless prevented by system design.

- Lack of up-to-date data available on infrared signature of small propeller-driven aircraft.

- No easy, reliable way to obtain range measurements on intruders.

To Order Paper No. 58R ...

... on which this article is based, turn to page 6.

Design Tips for Using

Based on paper (50R) by

Frederic H. Pollard

Republic Aviation Corp.

VITON A can be used satisfactorily for molded O-ring seals in hydraulic cylinders and other components over a temperature range of -65 to +600 F. But it is essential for success to design with the properties and characteristics of this elastomer in mind.

hardness

The basic Viton elastomer is much harder than Buna-N, consequently O-rings should be compounded to 85-90 durometer to have satisfactory properties. Tests of compounds cut back to produce a 70-durometer material proved valueless and failed quickly. There is nothing sacred about the traditional 70 durometer for hydraulic O-rings, so let's forget it for Viton.

The increased hardness and stiffness of Viton have little or no effect on dimensional require-

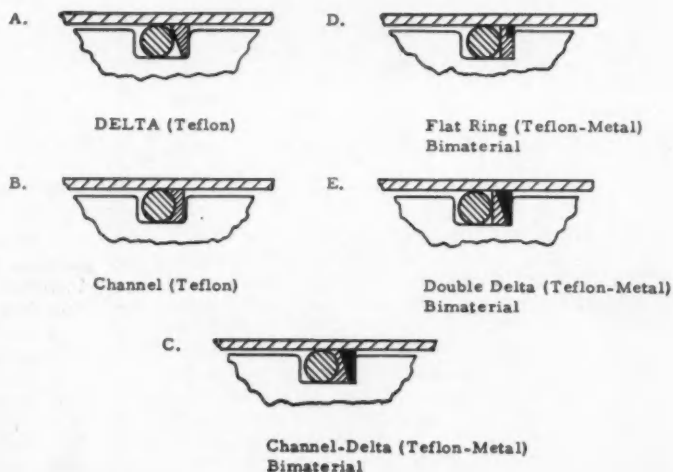
ments of seal installations. At the end of long tests at high temperature, the hardness will increase slightly (3-5 points) above the original.

thermal range

Tests show the usable thermal range to be -65 to +600 F. At 800 F Viton has very little life. At 680-730 F, tests have been successful, but its life is reduced to about 30-40 hr. At temperatures in the order of 550-600 F it has exhibited long and consistent life. Based on experiences at Republic, no other elastomer currently available would be considered for temperatures in excess of 300 F.

Time-honored flexibility tests of O-rings indicate a minimum usable temperature of -40 to -50 F, however, these tests are based on the ease of flexing over a given size mandrel. Most elastomers become hard and brittle and break or shatter in the flexing test when they reach their minimum usable temperature. Viton merely becomes stiff. This characteristic led us to make tests at -65 F and successful sealing resulted, if other conditions enumerated were complied with.

Fig. 1 — Backup ring configuration has a marked effect on the proper sealing of O-rings.



Viton

mold shrinkage

Viton exhibits a greater shrinkage in mold curing than Buna-N, hence O-rings will have smaller dimensions than the standard rings when processed in molds based on the characteristics of Buna-N. The basic factor to be used is 3%. This applies to both inside diameter of the ring and the sectional diameter. Moreover, it is recommended that stretching of the ring be limited to 2% as measured on the surface contacted by the inside diameter, whether it be the groove bottom (in the case of an external groove), or the piston rod (in the case of an internal groove).

In view of the relatively small use of Viton at present and the cost of making special molds to compensate for Viton's shrinkage, it would seem smart simply to recognize a difference in size and design and allow for it.

fluid effects

Viton is relatively unaffected by various high-temperature hydraulic fluids. It is where an O-ring

installation is to be used in two or more fluids, one of which produces a very considerable swell and the other either a very little swell or slight shrinkage, that an unsatisfactory seal results. The very high swell fluid so expands the ring that it is forced to take permanent set against the groove and sealing surfaces. Then, when the seal is used with low swell fluid and reduces in size, it no longer has sufficient squeeze to effect the desired contacting force and leakage results. For fluids that have a free soak swell of -2 to +15% no special design considerations need be taken with Viton or any other elastomer.

extrusion gap

The limits of diametral extrusion gap for normal temperatures are generally expressed as a function of the sectional diameter of the seal, and vary from 0.004 to -0.010 in. At elevated temperatures the extrusive force is no greater, but the resistance of the rubber and any antiextrusion devices (backup rings) to the extrusive forces is greatly reduced. For normal service life, therefore, it is necessary to reduce the limits of the diametral extrusion gap to 0.002 in. wherever practicable in the case of rings with a nominal section of 1/16-, 3/32- and 1/8-in. nominal section rings, and 0.005-0.007 in. in the case of 3/16- and 1/4-in. nominal section rings. This presents a design penalty and a cost penalty, but they are relatively minor when compared with other design and cost penalties which must be faced in high-temperature design.

other characteristics

Viton has excellent abrasion resistance as well as resistance to thermal cycling. In several tests, Viton was sealing just as well at room temperatures and also at reduced temperatures after 40 thermal cycles as it did when new. Other elastomers after two or three thermal cycles would no longer effect a seal at room temperature. Even Buna-N with repeated cycles to 275 F does not appear to have the thermal cyclic life that Viton does at 500 F.

Backup Ring Design Affects O-Ring Life

Based on paper (50S) by

C. E. Hamlin

Autonetics, Division of North American Aviation, Inc.

INVESTIGATION of various O-ring compounds reveals Viton A to have the greatest high-temperature potential for use in silicate-ester-type fluids. Its superior compression set characteristics probably account for the fact that sealing can be achieved at -65 F even though the O-ring is hard to the point of brittleness.

High-temperature tests have proved backup ring configuration to be a critical factor in the ability of

an O-ring to seal properly. On installations where spiral failure may be anticipated, rings A, B, and C, shown in Fig. 1, are recommended. The principal disadvantage of the plain delta ring (A) is the tendency of the O-ring to deform into the unoccupied space at the bottom of the groove. This deformation, coupled with compression set of the O-ring, results in loss of original squeeze, particularly noticeable at high temperature.

The channel backup ring (B) has been used with success. This design helps to prevent spiral failure and lends peripheral support to the O-ring. After dynamic tests of 50,000 cycles at 500 F, the seals still looked like O-rings rather than D-rings or delta rings. The channel design was found to be par-

Viton

... continued

ticularly advantageous in instances where the O-ring was on the low side, or below AN tolerances. On several occasions O-rings were assembled in a piston groove using single-turn Teflon backup rings. Excessive leakage developed after a few cycles at room temperature. With the single-turn rings replaced with channel backup rings, 50,000-cycle tests at 500 F were completed successfully. Tests at 500 F were run with Viton-A O-rings.

Diametral Deflection

Backup ring designs D, E, and C may be used to advantage on assemblies where high diametral deflections of the cylinder body are anticipated. These are bimaterial rings so designed that pressure exerted on the face of the ring causes it to expand outward. The expansion enables the outer periphery of the backup ring to remain in contact with the cylinder wall even during high deflections. The gap between the cylinder wall and the piston gland remains effectively closed, thereby preventing extrusion of the O-ring.

To test the effects of very high pressure, we made an experimental thin-walled cylinder 5 in. in diameter. The piston had one O-ring and two double delta backup rings, as shown in E. The actuator was operated under a hydraulic pressure of 4000 psi. The resultant diametral deflection of the cylinder wall was 0.020 in. The total piston excursion was 12 in. This distance was traveled in 1-in. increments with 5-min dwell periods at each increment. Six full excursions were made and no leak occurred at any time.

On disassembling the actuator the O-ring was found to be in excellent condition. No evidence of extrusion or pinching of the seal could be seen. This test indicates the possibility of using thin-walled, high-deflection cylinders when the O-ring is properly backed up.

The number of cycles over which a given dynamic seal can operate seems to depend to a great degree on the type of backup ring used. A backup ring and groove of the proper design will increase significantly the life expectancy of dynamic O-ring seals, regardless of the operating temperatures.

In addition to the tips to users of Viton, as presented in this article, the complete paper (50R) contains a table giving recommended groove, installation, and mating element dimensions for O-ring sizes 001 to 460.

▲ To Order Papers No. 50R and 50S...

... on which this article is based, turn to page 6.

storage+arithmetic

The Modern

Based on paper by

Arnold D. Hestenes

General Motors Corp.

FIVE basic units form the modern electronic computer:

1. Storage
2. Arithmetic and logic
3. Control
4. Input
5. Output

The storage component, often called the memory, is a device for retaining information for later use. Designs which have two stable states can be used as a memory unit. The most common instrument used in electronic computers is some form of magnetic recording. The primary memory is usually made up of little doughnut-shaped objects called magnetic cores. Six cores are needed to store one alphabetic or numeric character. Usually a seventh is used for checking purposes.

Cores have the advantage of being stable, independent of power, on or off, and are readily accessible in the electrical sense. Secondary storage is usually in the form of magnetic tape, magnetic drums, or magnetic discs. On these the information is retained in small magnetized spots and is read or written by read-write heads in much the same way information is recorded or played back on a home tape recorder.

The memory device plays a triple role in the computer: 1. it retains information associated with the task at hand; 2. it retains the instructions which inform the computer what it is to do with this information; and 3. it provides a working space for the computer.

To use the memory, some reference system must be established. A location within the memory is referred to as an address, much as your home is located by an address in a certain city. Various addressing systems are in use; however, for this discussion only the existence of a logical and unique reference system is necessary.

The arithmetic and logic component is that part of the computer which carries out the arithmetical and logical operations. The arithmetical operations are the usual ones of add, subtract, divide, and multiply. Logic operations are less familiar. Illustrative of this group are compare, shift to the left or right, round, transfer data, and halt.

and logic+control+input+output=

Electronic Computer

There are 50-60 operations, also called instructions, which a computer can perform. There are arithmetic, logic, input-output, control, and miscellaneous instructions. These instructions are coded and hence appear in the same form as data and are stored in the memory device just as any other data is stored.

The instruction consists of two or more parts, depending upon the particular design of the computer. One part specifies the operation to be performed; a second part refers to the location (the address) of the data which is to be involved in that operation (the operand). If additional parts are present, they represent either the address of other operands or of the next instruction.

The control unit interprets the instructions and electrically organizes the computer to carry out the intended instruction. In essence, then, the control component is the heart of the computer, for it is responsible for the proper operation of the entire system.

The input unit is a device through which man can communicate with the computer. Punched card readers, punched paper-tape readers, magnetic tape readers or direct keyboard entry are the normal ways of bringing data into a computer.

The output unit brings information from the computer to the outside. This can be in the form of punched cards, punched paper tape, magnetic tape, and printed reports.

The five components are interrelated. Fig. 1 illustrates the flow of information and control through the system.

A Versatile Tool

The electronic computer is a very powerful but versatile tool. Its repertoire of instructions contains a set of decision elements. Through the use of these decision elements, the computer can change its course of action during processing, depending on the results of the processing itself. This ability has given the computer the name "electronic brain". In reality, however, the computer can select only one of a set of predetermined courses of action; therefore, it is the analyst who prepares the program who must recognize and prepare adequate solutions to all possible alternatives.

The fact that the instructions themselves are stored within the memory in coded form provide the ability to alter and create instructions as the program progresses. The computer can recognize a group of characters as an instruction or as a col-

lection of data. The operations provided are applicable to the characters which form an instruction just as well as to characters which represent data. Consequently, computers have the ability to modify instructions.

The speed with which these computers operate is the speed of electronics and is measured in millionths of a second; therefore, jobs which require weeks or months by manual methods can be done in minutes by electronic methods. Not only are these machines fast but they are fantastically accurate. Electronic data processing is by far the most accurate method of data processing and scientific computing which is known or in use today.

To Order Paper No. 39R . . .

... on which this article is based, turn to page 6.

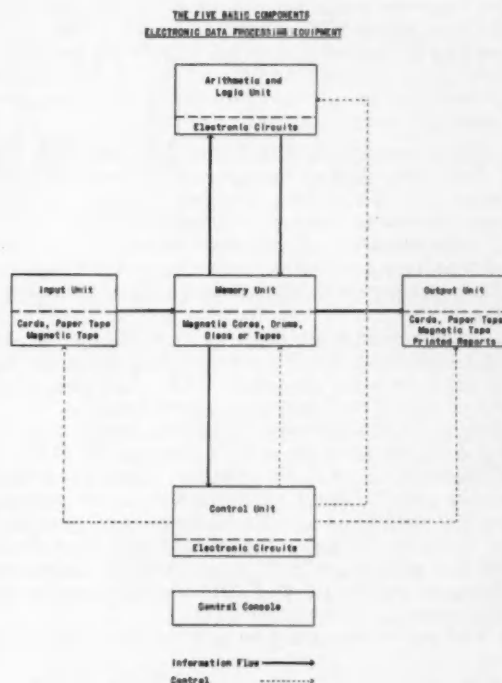


Fig. 1 — The five basic components of electronic data processing equipment.

*On the way to meet
needs of future are*

NEW AUTOMOTIVE PRIMERS

Still more improvements to be ready 2 years hence, besides those brought to production since 1950, when car makers put new emphasis on primers.

Based on paper by **J. D. Skandalaris***
Chrysler Corp.

NEW developments in automotive primers are in the cards for two years hence. They will register major improvements on top of those brought into production since 1950, when automotive companies began to put new emphasis on improving primers.

These near-future primers, unlikely to be released for production for at least 24 months, will bring better results in several areas:

1. Developments in the resin field, for example, will yield still further improvements in automotive finishes. . . . Water-base primers, already a reality, possess desirable flexibility characteristics; eliminate some fire and toxic hazards when used in place of solvent-using primers. More important, the water-base primers will eliminate costly waste of solvents.

2. Improvements in flash primers will allow the automobile manufacturer to cure both primers and color coats in a single bake. This will bring about savings in both equipment and floor space.

But paint departments will have to be given better metal surfaces to work with if they are to take full advantage of these flash primers. They apply successfully only to body surfaces which are smooth; which are free from file marks and other irregularities. Besides, the paint formulator will have to improve the general holdout properties of the primer to produce resultant wet films insensitive to the strong solvents of the color coat.

3. The car maker may be able to coat portions of

bodies by dip methods not readily accessible to spray guns . . . and to flow-coat the remaining surfaces in one station with the same materials.

This process could result from development of epoxy flow-coat and/or dip primers which will produce maximum film thickness at application viscosities. This would result in a finished car having maximum protection over its entire inner and outer surfaces. It would then prevent corrosion from occurring from the inside to the outer portion of the body surfaces.

While these further breakthroughs are being made in the next few years, studies are being encouraged on grinding techniques, special pigments, driers, and so forth. Thus, primers having maximum holdout and ease of sanding can be formulated to result in color coats having a glass-like finish under all manufacturing conditions.

Current Developments

Developments of the last eight years have brought into production primers — using epoxy resins — to meet the new and stiffer requirements born of changing car design and use.

These epoxy resins have some very unusual advantages . . . and — as compared to other coating vehicles — some disadvantages. Their advantages include:

- Extreme chemical resistance.
- Adhesion to a wide variety of surfaces.
- Excellent flexibility, particularly at low temperatures.
- Low moisture permeability.

Their limitations — which producers are working to overcome — include:

- Limited compatibility with other finishing vehicles.
- Need for relatively high braking temperatures to obtain complete conversion.

The many desirable qualities of the epoxy resins, however, have permitted primers to meet new needs, such as the new emphasis on corrosion protection resulting from the tremendous increase in use of salt on roads.

Maximum humidity resistance has also been built into primer formulations to prevent blistering and metal corrosion by galvanic action caused by some new metal moldings which entrap moisture and, under certain conditions, produce an efficient humidity chamber.

Developed also have been primers with maximum flexibility both initially and after aging under normal and accelerated conditions. This development was necessitated to counteract the results of higher speed driving on gravel roads, which has made stone and/or gravel impact more and more severe.

Desirable properties of current primers at low film thickness also prevent paint chipping on panels which taper to a point with very little radius. The film thickness resulting in such design areas (because of minimum surface area for sanding after bake) is normally below the critical minimum required of an alkyd primer.

* Skandalaris is chairman of the Organic Coatings Subcommittee of the SAE Nonmetallic Materials Committee.

To Order Paper No. 36R . . .

... on which this article is based, turn to page 6.

Cutting Costs and Speeding Design



Dramatic evidence of what a single human hair in the die did to a steel panel stamping.

Are keynotes at SAE's first Automobile Week

A SINGLE HUMAN HAIR grooved a steel panel stamping for an area more than a quarter inch wide by the length of the hair. This was one of the dramatic pieces of evidence supporting die cleanliness at the Production Forum held in conjunction with SAE Automobile Week in Detroit, March 16-20.

The trend toward a complete new car design every year also left its stamp on the meeting. Engineers heard of rapid and complete test techniques that screened designs for automatic transmission and drive line components, body

strength, and torsional suspension systems. Production men reflected this industry-engineering speedup with information on electronic data processors.

Cost-cutting continued to be the ever-present partner to design. One example is the production of a steel nut that accumulates 11,000 tons of chips a year. A cold-forming pilot line promises to cut chips to 500 tons a year. This results from eliminating all but two of the machining operations on the nut.

The die cleanliness problem il-

lustrated above is actually one of keeping metal finishing costs down. One solution is to close the dies on a sheet of polyethylene before the start of a run. The sheet picks up foreign matter.

Dents and scratches may cost more to remove than the part is worth.

And this doesn't take into account the new scratches and dings that often result from the extra handling for reworking. These high reworking costs are especially applicable in cases of plated or anodized parts.

Capsules of technical sessions and production panels on pages 86-89

Capsules of Technical Papers from SAE Automobile Week

Indoor Testing — In laboratory defroster tests at Ford, one quart of water is sprayed over every 500 sq in. of windshield area to get a frost layer whose thickness varies less than $\pm 5\%$. (Paper 30S)

Laboratory testing of automatic transmissions is not a substitute for proving ground trials. But they do have the advantage of permitting close investigation of the operation of inaccessible parts. Also, the delay of transmission tests due to failure of other vehicle components is limited. (Paper 30R)

European Trucks — In Europe, the truck trend has been from the normal toward the forward control type of vehicle; more recently, to the full forward control. The "golden aim" — to produce a single layout incorporating advantages of both, compared with economic and production advantages of one type of cab — has yet to be achieved. Most manufacturers produce at least two main types to retain a competitive range suitable for worldwide sale. (Paper 31R)

Present-Day Approach to Fatigue — Micro-plasticity and surface behavior are two areas of fatigue research of fundamental, current interest. Micro-plasticity studies will develop data on low cycle fatigue, thermal cycling, fatigue accelerated creep, and relaxation of residual stress due to repeated loads. Surface behavior studies are showing how fatigue life of metals can be changed appreciably by air humidity content, oil and grease coatings.

Chrysler seems to have gone far toward proving the usefulness of production fatigue testing, which some have considered a fairly radical approach to production control. Their application of fatigue testing to quality determination of front suspension torsion bar springs reveals interesting results from this line of attack. (Paper 32S)

American and Foreign Light Car Analysis — The rear fenders, the front fenders, and the apron assembly of the new "Lark" are

bolted on. In shortening the rear end overhang, and at the same time maintaining trunk height, the rear panel resulted in a substantially vertical surface. Rather than incorporate this area in the deck lid, a full-width rear panel was designed as an integral structural part for body rigidity. (Paper 33T)

In the new Hillman "Minx," which has a unitized body, the front fender panels and the rear fenders are welded into the basic structure . . . and the main longitudinal side-members run the whole length of the understructure, independent of the body sills. (Paper 33R)

The Goliath front-drive car is manufactured by Goliath-Werk GMBH in Bremen, West Germany; sold in the United States through Goliath Sales Corp. of Burlingame, Calif. The car has a flat 4-cyl, 46-hp engine, with a wheelbase of 89.37 in., and unloaded weight of 1896 lb.

Electronic Techniques for Testing Passenger-Car Bodies — Deflections in body structures must be carefully evaluated to avoid car shake problems . . . and great strides have been made in recent years in development of test procedures to achieve this end. (Paper 34R)

Electronic equipment is being used to solve an ever-increasing number of body mechanism problems, such as what makes some mirrors shake and blur while others do not; plotting of shake studies (with X-Y plotters); and any of the various kinds of sound studies. (Paper 34S)

Development of an acceptable ride index requires flexible instrumentation so that new indices can be readily evaluated. Magnetic tape and computers are ideal. Recorded signals on tapes can be used over and over . . . and as new ride indices are proposed, they can be evaluated from original tapes without returning to the road for additional measurements. (Paper 34T)

Multipurpose Bodies — from Plush Pickups to Pint-Sized Pullmans — The increasingly popular multipurpose passenger-car body serves many purposes today for many different kinds of people. To the farmer it gives passenger-car comfort and hauling ability of a pickup truck; to the sportsman — storage space for hunting, fish-

ing, or boating equipment and camp-site living quarters; and to the motor vehicle manufacturer an economical means of widening his market and using existing tools to maximum advantage. (Paper 35R)

New Automotive Finishes — Gloss retention is the chief claim made for acrylic lacquer, a recent development in the automotive painting industry. The new lacquer is a poly-methyl-methacrylate . . . a plexiglass or lucite. (Paper 36S)

Improvements just around the corner in primers for automobile bodies include elimination of some fire hazards by water primers being available instead of solvents; flash primer improvement permitting cure of both primers and color coats in a single bake; and primers which will produce a maximum film thickness at application viscosities. (Paper 36R)

Reduction of in-plant repairs accruing from methods developed to apply the new super-finish enamel for passenger cars actually produces a car at lower paint cost than with conventional enamels. . . . And these new finishes are turning out to be every bit as good as earlier researches indicated, car engineers say. (Paper 36T)

Components Affecting Ride and Handling — Valuable clues can be found in the laboratory to establish tire ride and handling characteristics . . . and are sufficiently clearcut to be checked on the road by experts — Firestone's "trial by jury" method shows. (Paper 37S)

The low profile tire improves car stability, decreases power consumption, improves tread mileage, and reduces squeal. Its only disadvantage is a slightly harder ride. (Paper 37T)

Use of a Freon 13-filled nylon cell — sealed with adhesive — in direct-action shock absorbers results, among other things, in accomplishment of adequate wheel control. Lighter valving than was possible with previously standard designs, also resulted. (Paper 37R)

Passenger-Car Exhaust Systems — New and relatively simple solutions have been developed recently to the problem of measuring the velocity of sound in connection with muffler research, despite the relatively high temperatures of the gases involved. (Paper 38R)

Cold accoustical testing of mufflers has been found to be a most reliable research tool. Alone, it will not provide the answer . . . but, used with dynamometer and on-the-road testing, its value will become increasingly evident. (Paper 38S)

Each muffler must be designed and located for the specific application, if best use is to be made of space and money, recent tests confirm. (Paper 38T)

Acid test condensate and its effect on mufflers can and is being controlled to an acceptable limit by use of hot dipped zinc, aluminized steel, and by design. (Paper 38U)

Electronic Data Processors — "SACIO" stands for the five basic components of an electric computer: storage, arithmetic, logic, control, input, and output . . . but a secondary meaning is: "Something About Computers in 10 minutes!" (Paper 39R)

As each new area for computer applications is explored, new use possibilities keep developing . . . many of them in use of electronic data processing equipment for quality control. (Paper 39S)

Chevrolet is using an IBM Type 705 Electronic Computer Data Processing Machine to control many phases of producing, processing, warehousing, and distributing over 50,000 different parts and accessories. It is realizing improvement by way of reduced human effort, reduced inventories, and improved service to customers. (Paper 39T)

Ford's M-E-L Division has in operation a computer program by which a fairly accurate one week's forecast of just what its plants are going to build is available at any time — exclusive of such factors as blizzards and other normal hazards of the manufacturing scheduling business. (Paper 39U)

Sprayed Metal Coatings — Protection against oxidation and corrosion at elevated temperatures — and corrosion at ambient temperatures — is possible through proper selection of metals and procedures. (Paper 40T)

New developments in fused sprayed metal coatings open the way to metal forming die repair using these methods. Production-wise — these coatings can easily be automated. (Paper 40S)

The "flame ceramic" process



THINGS WERE POPPING at the Blue Ribbon Luncheon, and "Toastmaster" J. Adams (rear) made it literal when he timed speakers with a slice of bread and a toaster. Harold Warner, W. B. Shimer, and Anderson Ashburn (left to right) judged talks given by a spokesman from each luncheon table. The winning talk was on "How to tell your boss he is wrong."



Toastmaster Heinen tries out some of his opening remarks on participants at the dinner meeting. Leroy E. Burney, Surgeon General, U. S. Public Health Service, (second from right) delivered the dinner speech on the cooperation needed between the Public Health Service and the automotive industry on accidents and air pollution. Detroit Section Chairman W. E. Burnett and SAE President Leonard Raymond (left to right) listen to Heinen's remarks.



Forest McFarland, vice-president of Passenger Car Activity recounts future plans as Production Activity Vice-President Anderson Ashburn listens.

SMALL CARS drew a crowd after the session on American and Foreign Light Car Analysis. Foreign cars displayed were the Hillman and the Goliath.



Technical

Capsules . . . continued

permits a coating such as zirconium oxide, which does not melt until nearly 5000 F, to be applied to metals, glass, and other resistant bodies at surface temperatures not exceeding a few hundred degrees. (Paper 40R)

Have You Forgotten Something?

— Important details are often overlooked during new product planning. Factors frequently overlooked in selecting machine tools for automatic production operations are flexibility, accessibility, tool changing, electrical arrangement, work height and identification. (Paper 41S)

Emphasis has been placed on smaller machines, specifically designed for the particular job, at Timken's ultramodern roller bearing plant at Bucyrus, Ohio. Great savings in plant production space are thus achieved, as compared to application of widely adaptable standard machines. The latter would have been more complex and much larger. (Paper 41T)

Close contact with the product engineers enables the manufacturing group at Saginaw Steering never to be surprised when a part is released for production. Before release, they are familiar with durability tests, function tests, laboratory and proving-ground tests. Their questioning attitude in these early stages demands that the product engineer design for low cost as well as function. (Paper 41R)

Quality, FOB — To prevent sheet metal from rusting in unitized bodies, American Motors now submerges the entire body in paint primer. Specially designed equipment is used which can handle up to 50 bodies per hour. (Paper 42R)

One way to measure customer acceptability is to consider repairs performed by dealers at customers' requests as negative customer reactions. These can be readily identified and measured . . . and used constructively in the development of quality standards. (Paper 42S)

Papers on which these capsules are based are available in full in multilith form from SAE Headquarters. See order blank on page 6.

Capsule reports of 8 production panels

Build a Plant or Remodel?

Advantages of a remodeled plant are: early production start, reduced preliminary planning, available labor and transportation, accurate utility costs. However, the plant must meet your functional requirements, and even so maintenance and alterations may be expensive. Also, the labor may be untrained for your industry.

Prospective new plant builders should give particular attention to scrap disposal systems, central coolant systems, bay sizes, floor loadings, location of permanent installation so they don't interfere with future expansion.

When you are selecting real estate for a site, check these points: future expansion and parking, utilities, drainage, zoning, taxes, title problems, and obtain test borings before making a commitment.

How To Save Valuable Floor Space

Four ways to save floor space are:

- Use roof and ceiling areas for drying and other light weight equipment.

- Eliminate conveyers that take floor space. Two examples are under-floor conveyers and vertical magnetic conveyers.

- Integrate production. An example of this is the use of progressive dies and a Transmat press, which produced 1200 pieces an hour and occupied 840 sq ft. To set the same job up on separate presses would require three lines of four presses each, and take 3460 sq ft of floor space.

- Indirect intergration of production. This method eliminates manual product handling, stock containers, trucking, or even conveyers. This technique was achieved in the production of a speed indicator tube, which required trimming, piercing, washing, drying, painting, and silk screening or decals. Only a conveyor was used as a stock float.

Computers Screen Customers' Orders

Electronic data processing is one answer to the problem of gaining time in the analysis and screening of customer orders. Analyzation must be done quickly if manufacturing schedules are to be changed to bring production effectively into line with dealer and customer requirements.

A large passenger-car producer reported that substantial savings could be made if, during slow periods, production was continued at straight time tooled capacity. Extra components produced were warehoused. This bank was drawn on to meet peak demand.

A permanent liquidation of 55 pct of a previous inventory account was reported as a result of using a group of flexible, special purpose machine tools with permanent setups. Cost of the machines and tooling was 25 pct of the inventory. Fixed setups were provided for each operation on each size and style of product. With setup time eliminated, it became possible to produce 6 parts or a thousand parts with equal economy.

Saving Time and Money On Tooling

The best tools are usually the simplest tools the panel reported, because they are usually low cost tools and cost less to operate and maintain.

Here are some tips about things to look for in reducing tooling costs:

1. Eliminate back-draft.
2. Reduce areas where flange angles are more or less than 90 deg.
3. Design contours so part can be held in the flanging position without danger of "creep."
4. Provide fastening holes so piercing can be accomplished without cam dies.
5. Avoid contours, which require draw, redraw, reform or restrike.
6. Keep in mind the material with which you are working.
7. Avoid designs having critical dimensions.
8. Combine parts — avoid multiple-piece construction.

The use of Kirksite for lugs was recommended on trim and pierce dies. Pads can be iron or steel with plastic facings. This eliminates Kellering and barbering. An air cushion that will operate either in the bottom of a press or the top of the press was suggested.

The next two years will see important break-throughs for electrical discharge machining in blanking dies, cavity dies, powdered metal dies, press work dies, and cold heading dies, it was predicted. Ability to have punch manufacture independent of die

clearance is an important forward step. A metal removal rate 6-10 times faster than Kellering was claimed for electrical discharge machining.

Cold Forming

The outstanding characteristic of cold-formed parts—in addition to remarkable size control and high production rates—is the fact that a ton of steel makes nearly a ton of finished parts. The chip box and chip handling practically disappear.

Predicting the behavior of materials in a cold forming operation is not simple. In many instances, materials that machine readily are difficult to cold form. Conversely, certain materials that work well on extruded products are hard to machine.

Where proper precautions are taken and techniques are worked out carefully, the reward may be a little short of sensational. For example, many products are being cold formed at less than the previous cost of the materials alone.

Some interesting experiments are going on in the field of cold forming. The use of much faster forming rates looks promising, but work in this area is just beginning.

Reduce Metal Finishing Cost?

Attention to details is the key to low metal finishing cost. Here are some suggestions presented by panel members:

With respect to press tools:

1. Keep all breaks or initial draws in the binder area and avoid marking by proper stripper design.

2. Close dies on a sheet of polyethylene before starting a run. This picks up foreign matter.

3. Spray special materials on blank sheets where draws are difficult.

Shaking rigs are being used successfully to pre-analyze shipping conditions.

To avoid panel damage, give proper attention to clamping pressures and provide adequate clearance in swinging clamps and locators.

Design engineers should avoid solder joints in difficult metal finishing areas. Slotted rubber wheels for abrasive sleeves are gaining acceptance.

The use of the flowing abrasive principle is reducing finishing costs prior to plating. This is a form of tumbling in which parts

are immersed in a barrel and abrasive is flowed around them.

Correcting Assembly Troubles

Comparing the tolerances demanded today by the passenger-car industry with those of even the postwar years is like comparing a micrometer to a yardstick. Automatic gaging of 100% of production is reducing large banks of parts. In some areas, roller and bearing assembly, for example, automatic gaging is eliminating the size grading of inner and outer races. Qualified parts are fed to an automatic assembly gage. In final assembly, two-thirds of the sorted banks of parts, that is, inner and outer races, is eliminated.

The automobile industry also has the problem of testing individual parts and assembly for noise level and assuring the customer that noise will not be objectionable in any car produced. Experience has shown that a differential that is noisy in one car may not be objectionable in another. The slightest variation in an assembly may be a cause for rejection because of noise.

At the present time, electronic equipment is not available for noise testing of mass-produced automobiles on the production line. Efforts are being made to correlate noise in the vehicle with sounds detected on individual test stands. The problem is multiplied by the number of body styles.

Can We Have Work Measurement for Preventive Maintenance?

The answer to this question is an emphatic "Yes," a panel member asserted—provided the necessary steps are taken.

Once procedures have been set up and the maintenance man's duties are defined, it is a comparatively simple matter to establish reasonable times for performing the work required.

In the refining business, planning and scheduling of maintenance work have played a big part in controlling maintenance costs. Included among the benefits credited to this refinery program are the following: An appropriate number of men and crafts are assigned to each job; work effectiveness is made available; long-range planning is improved; work requests are more accurate and complete; unnecessary work is eliminated. The outstanding advantage



Production Panels Leaders had a chance to get acquainted at a reception before the Production Forums. At top are (left to right) John van Rosen, Chrysler Corp.; D. J. Davis, Ford Motors Co.; B. F. Starr, Pontiac Motor Division, GMC; and Haywood Gay, Cincinnati Milling Machine Co. Below are (left to right) Hugh Arnold, Argonaut Realty Division, GMC; Carl Benson, Cadillac Motor Car Division, GMC; A. J. Hole, Ford Motor Co.; and J. F. Kerigan, Chrysler Corp.



Engineering Materials Vice-President Nixon (left) entertains Richard Wantin and J. W. Shank before they head for dinner. Wantin and Shank (center and right) are vice-presidents of the Truck and Bus, and Body Activities, respectively.

of planned maintenance is that maintenance costs can be reduced *without hurting quality*.

Preventive maintenance standards worked out by another firm describes work to be performed by every craft on every piece of equipment. Each sheet describes the job, states frequency, standard hours and manpower. The entire program is conducted on pre-punched cards.

Secretaries' reports of these panels will be available in full in multilith form as SP-326.



MEET THE AVIATION PRESS LUNCHEON featured panel of newsmen who quizzed panel of industry leaders on "The Supersonic Transport." Newsmen were Richard Witkin of the "New York Times," Mary Hornaday of the "Christian Science Monitor," George Carroll of the "New York Journal-American," and Edwin Pipp of the "Detroit News." Ansel Talbert of Flight Safety Foundation moderated. Industry panelists were Christopher Clarkson of Vickers-Armstrongs, Robert Cummings of New York Airways, Gen. Harold R. Harris of Aviation Financial Services, Inc., William Littlewood of American Airlines, R. C. Sebold of Convair, and Gen. Claude Teyssier of Sud Aviation.

New York Aeronautic Draws More Participants, Bigger

THE traditional spring SAE National Aeronautic Meeting was held March 31-April 3 in the Hotel Commodore in New York City.

Seventy papers were presented in 28 sessions, including two classified sessions cosponsored by the New York Regional Office of the Air Force's Air Research and Development Command. In addition, there were three clinic-type discussion sessions, two luncheons, a dinner, a score of committee meetings, and the four-day SAE Missiles and Aircraft Engineering Display.

Attendance at this Meeting rose 25% over that at the similar Meeting a year ago, and 38% more preprints were sold—statistics that gladdened the scores of men who had worked for almost a year to plan the Meeting or to prepare its technical content. The planning committee was headed by Robert W. Middlewood, director of Lockheed's Georgia Nuclear Laboratories, and Kenneth W. Stalker, manager of manufacturing engineering and process development for General Electric's Aircraft Gas Turbine Department.

Walter L. Flinn, Jr. of Vickers' Washington office led an active

pre-Meeting publicity group. M. G. Beard of American Airlines arranged the dinner.

Attendees were treated to an intensive course in "what's new" in manufacturing engineering, fuels and engine design, airline operation, and space propulsion. By the end of the week, many participants had added these terms to their vocabularies:

jet cutter—a device embodying a very fine stream of water for cutting tough steels. The impinging stream actually erodes away a tiny channel and cuts the steel. This device was suggested as a means of shaping the stainless steels that shops may be handling 10 years from now when they are building supersonic transports and interplanetary vehicles.

luminometer rating—a measure of a turbine fuel's tendency to radiate heat. Excessive radiant heat can damage structure it strikes.

pyrophorics—fuels that ignite on contact with air, a quality that makes possible more reliable turbojet afterburners and higher-performance ramjets but complicates fuel handling.

fuel cell—a means of convert-

ing the chemical energy of gases directly into electricity. The cell relies on hollow, porous, catalyst-impregnated electrodes through which the gases enter the cell and which also conduct the electricity produced by the electrochemical reaction.

supercavitating hydrofoil—a hydrofoil shaped to form a vapor cavity enveloping the whole suction face so that the cavitation bubbles are carried well beyond the trailing edge and collapse harmlessly in the water aft of the foil. This "supercavitation" reduces drag. It's most effective above 65-75 knots. One aircraft builder is studying application of these hydrofoils to passenger vessels.

oceans—bodies of salt water on or through which future products of some of today's aircraft producers may normally operate. That's because, as missiles become more deadly and transports more productive, there may be less airframe business. Companies now building flight vehicles are diversifying into such fields as submarines and ships to maintain their high volume of business.

Capsule reports on each of the



Robert W. Middlewood and Kenneth W. Stalker, cochairmen of the committee that planned the Meeting, make last-minute check.



SAE Metropolitan Section members T. B. Rendel, Carl Ryan, Sydney Tilden, and Leslie Peat served as reception committee.

Meeting Audience

Meeting's sessions follow:

Research Evaluates Machining

— The Air Force has set up a machinability research program to evaluate the machining characteristics of the more commonly used high-strength thermal-resistant materials. There is, at present, a lack of data for machining these materials in the high hardness ranges. Representative alloys being tested are AISI 4340, Vasco Jet 1000, AM-350, and A-286 steels. (Paper 43R — see p. 37 of this issue)

Electric Blanket Speeds Brazing

— Using the electric blanket brazing technique, with the precipitation hardening alloys, the complete brazing and heat-treating cycle for assembling honeycomb sandwich components is about 13½ hr. Conventional furnace brazing takes about 34 hr. In addition, the electric blanket operates at 65% efficiency, compared to the 10% efficiency of the brazing furnace. (Paper 43S)

Ceramic Tools Still in the Future

— The brittleness of ceramic cutting tools will have to be solved before they will find a place in production. This is still probably a couple of years away. (Fabricat-



Friendships were renewed in committee meetings and corridor encounters throughout the week.



George Berger (left), gifted student from Far Rockaway High School, discusses gas generators with John Thoele. Berger attended a number of technical sessions at the Meeting.



Dr. Arthur Nutt greets Capt. R. B. Laning, USN, an expert on nuclear-powered submarines, who reviewed for the first-day luncheon gathering new capabilities of undersea craft.



Dinner speaker C. W. LaPierre, a vice-president of General Electric, with R. W. Middlewood.



J. T. Farah, C. W. MacAllister, Mrs. Spears, and R. D. Spears share joke at pre-dinner reception.



Dean John R. Dunning of Columbia gets flower as Dean John R. Ragazzini of NYU watches.



Larry Myers of Alcoa, H. B. Ecker of Edgewater Steel, and William Helfrich of Pratt & Whitney.



J. D. Redding (right) with Britishers C. T. Hewson (left) and D. R. Murrin (background).

ing Ultra High Strength and Refractory Materials Panel—SP-327)

7 Steps to Problem Solution—GM's Process Development Staff uses a Planning Team Activity to improve quality of product and reduce manufacturing costs. Seven steps are applied by the team toward the solution of any problem: (1) Determine the problem or objective; (2) study the conditions;

(3) plan possible solutions; (4) evaluate possible solutions; (5) recommend action; (6) follow up to assure action; and, (7) check results. (Paper 44R—see p. 64 of this issue)

Planning Team Saves Dollars—Savings brought about by GM's Planning Team Activity have averaged better than three times the costs of investigation. One project

showed a savings to cost ratio of 11/1. (Cost Reduction Panel—SP-327)

\$4 Million Cost Savings—A cost improvement program introduced at ARMA Division of American Bosch Arma Corp. in 1956 has already produced savings in excess of \$4,000,000. Also, it has stimulated creative thinking by management personnel—by providing a channel through which their ideas can be transmitted to an impartial committee for investigation and evaluation. (Paper 44S)

Communications Is Key to Quality Control—Quality can't be inspected into a product but inspection plays an important part in quality control. Inspection must educate the worker through feedback information. Errors must be brought to the attention of the worker responsible. Thus, communications represent the key to successful quality control. (Guidance and Control Panel—SP-327)

Cost Reduction, a Plant Effort—Cost reduction is more important these days than ever before. But, to be achieved effectively, it must be carefully organized on a plant-wide basis, with more emphasis on overall system costs than the individual parts and pieces. (Paper 45R)

Imagination and Standardization—Job-shop methods need not be used in every phase of manufacturing of electronic guidance and control units. Imagination applied to the tactical problems of standardization can result in designs producible by efficient manufacturing methods. (Paper 45S)

Air Force Criteria for Reliability—The Air Force uses 10 criteria for evaluating reliability programs: (1) concept and approach; (2) organization; (3) programming; (4) quality control; (5) requirement studies; (6) qualification testing; (7) acceptance testing; (8) failure reporting; (9) vendor relationships; (10) training (human behavior). Of course, human behavior is the toughest one to measure. (Product Reliability Panel—SP-327)

Let Them Know "Why"—Plant communications can be improved by supplying the "reasons why" to all receiving a communication. A member of the team, in the know, needs no further incentive to exert his best efforts with real pride. (Paper 46R)

Reliability Presents New Chal-

lenges — The production man must meet the reliability requirements of the space age. Production processes will have to be mechanized. Where this isn't practicable, the worker will have to be motivated to provide the utmost in careful workmanship. Inspection, control and screening processes will have to be strengthened and measurement standards will have to be further refined. (Paper 46S)

Kerosene Fuels for Jet Transport — No safety-of-flight problems have occurred due to use of kerosene fuels in jet commercial aircraft. Nuisance problems, such as those hindering rapid and accurate ground refueling, are being corrected. (Paper 47R)

Detecting Fuel Contamination — If fuel contamination in aircraft engines can be accurately detected, equipment already exists to cut contamination to a fraction of what is considered acceptable today. But "accurate" means indication of fuel contamination levels on the order of 1-5 mg per gal. And in most cases so far, fuel contamination has been measured only where it existed in excessive amounts. (Paper 47S — see p. 52 of this issue)

Fuel Cleanliness Surveys — Fuel cleanliness surveys for airlines using aircraft turbines show the following:

- (1) The concentration of particle contaminants becomes less as fuel is moved through the distribution and dispensing systems from terminal storage to the airplane.
- (2) Fuel type is important when deciding on the degree of fuel cleanliness necessary. Kerosene fuel tolerates twice the load that JP-4 does before seizure. (Paper 47T)

Ground Handling of Commercial Jets — Facilities for towing and baggage handling have to catch up with jet transport. Wheel-moving vehicles have been proposed to replace tow trucks between the terminal and starting point. They should be lightweight, use airplane weight to develop traction, and have quick coupling and pilot control features. A preloaded container system is now being used to handle baggage on some Boeing 707 models. (Paper 48R)

Jet Engine Support — New jets have increased the requirements for support units — self-contained



DR. R. H. BODEN OF ROCKETDYNE (right) received the Manly Memorial Award for his paper on the ion rocket engine, judged the best SAE paper in 1958 in the aeronautical propulsion field.

G. N. Cole (left) made the presentation of the medal and the scroll. Boden gave the paper at a session on New Sources of Energy for Propulsion, which was part of the Aeronautic Meeting held in New York a year ago.

In accepting the award, Boden paid tribute to a man who 28 years ago provided Boden with money to do graduate work at Massachusetts Institute of Technology. Boden announced that on the way back to his home in California he was going to take the gold Manly medal to his benefactor, Frank J. Anderson, designer of much of the George Washington bridge over the Hudson.



Special clearance and badges were required for classified sessions on April 2, cosponsored by New York Regional Office of USAF Air Research and Development Command. Maj. J. F. Regan (at left, with mustache) was in charge.



Participants in session on High-Temperature Resilient Seals organized by SAE Subcommittee AE-3A were E. N. Cunningham, A. A. LePera, H. E. Todd, C. E. Hamlin, J. H. Swartz, F. H. Pollard, and A. B. Billet. Cunningham presided; Swartz was secretary. The others gave papers.



At the SAE Missiles and Aircraft Engineering Display . . .



and ground service. Continuous air source units for ground service include engine starting, cabin air conditioning, and combination units. Combination pneumatic service packages are often employed as part of a multipurpose vehicle to fulfill all ground support requirements of a family of aircraft.

Self-contained starting systems are used: (1) If it is important to get the aircraft into the air quickly. (2) If the aircraft is operated periodically from remote and widely scattered bases. (3) If the ratio of aircraft to operating bases is low. (Papers 48S and 48T)

Allison Model 250 — Allison designed this 250-hp gas turbine for shaft output with the following important features: (1) free turbine, (2) combustion chamber aft of engine, (3) components matched to favor cruise power, (4) axial-centrifugal compressor, (5) mechanical-hydraulic type of control system, (6) gearbox casting is main structural element. (Paper 49R — see p. 74 of this issue)

T53 Anti-Icing System — Lycoming bleeds hot air from the T53 compressor and passes it through passages within the walls of the surfaces to be protected. The 860-1000-hp engine has a noncontinuous anti-icing system with optional ice detector. This system protects the droplet impingement surfaces, such as the inlet guide vanes. Hot oil from normal engine operation protects the reduction gear housing and the lower strut. (Paper 49S — see p. 46 of this issue)

NASA Study of Engine Reliability — Overhaul times on military jet engines were low despite an extensive program of field repair. Foreign object damage was the most important factor leading to premature overhaul — affecting mainly the compressor blades of the axial-flow engine. Early failure was found in the compressor, combustor, nozzle assembly, turbine buckets and discs, bearings, and fuel control. (Paper 49T)

High-Temperature Resilient Seals — A major breakthrough in polymer technology, or development of "elastomeric-inorganic" materials will solve the sealing problem in high-temperature systems. The available fluoro-rubbers will no longer be adequate for sealing applications as system temperatures pass 600 F (at Mach

3) and climb toward 1000 F (Mach 4).

Maximum temperature of silicone rubber compounds is 500 F for successful use in seals. Viton A elastomer can be used at temperatures of -65 F to +600 F; it also has excellent thermal-cycling resistance. Failure during thermal cycling in the high-temperature range is one of the present difficulties with elastomeric seals. (Papers 50R, 50S, 50T, 50U, 50V. See p. 80 for more on paper no. 50R.)

Design of Weapon Maintenance

—Maintenance costs far exceed the initial costs of weapon system equipment. Design deficiencies contribute to this high cost in the areas of accessibility, visibility and legibility, ease of disassembly and assembly, component weights and dimensions, and test philosophy. Human engineering specialists can help solve these design problems. (Paper 51R)

Relaxed Alertness in the Cockpit—An opinion survey on the problem of retaining crew vigilance was conducted. It suggested that the design of cockpits should be considered on an integrated basis rather than piece by piece. More attention should be given to practical use (day-in, day-out) under varying conditions. The objective should be to avoid soporific monotony, distractions, discomfort, and restlessness. There is a need to train crews in cockpit discipline. (Paper 51S)

High-Altitude Decompression—The adverse effects of sudden loss of pressure in jet aircraft can be lessened by: (1) Control of maximum size of openings with respect to volume. (2) Crewmen physically able to cope with sudden decompression, and adequately trained for emergencies. (3) Damage-control engineering. (4) Rapid descent and oxygen supply to all passengers (stop-gap measures). (5) Above 50,000 ft emphasis on reliability, as above practices will not help. (Paper 51T)

Safety Expected from Electrodes

—Radical improvements are expected in the quality and performance of covered electrodes used in the metal-arc coated electrode process. These improvements will be in the low hydrogen type of electrodes, that will be nonhydroscopic and can be used without the present precautions with regard

to storage. (Paper 52S)

Plastic Deformation Shapes Materials—High energy rate plastic deformation appears to provide an answer to the problems of scale growth, oxidation of material, and heat transfer. Since each of these problem areas is dependent on time, reducing time to a minimum reduces their effects. Also, the high velocity working of metals permits greater stretching of the metals. To the producer of hardware, this means deeper draws, elimination of several annealing steps, fewer staging operations in forging or rolling and the producibility of more complex parts. (Paper 52T)

Auxiliary Powerplants—Auxiliary power unit requirements range in operating time from a few seconds to over a year; with power levels from less than one horsepower to over one hundred. They fall into three broad categories:

(1) The positive displacement APU combines the advantages of compact propellant energy and moderate rotating speed with high efficiencies. The hot-gas auxiliary-power unit is used principally for starting gas turbine engines; it also has short-time missile applications. The motor is a compact, self-contained secondary-power supply, capable of providing 1-50 hp for limited periods.

(2) The auxiliary gas turbine unit offers high reliability, low weight, economic, and maintenance advantages. A system integrated into the design of the airplane will supply engine starting requirements; inflight power demands; and compressed air for pressurization, ventilation, cooling, and heating of the cabin.

(3) Non-air-breathing auxiliary powerplants become main powerplants when the vehicle is in space. Batteries, fuel cells, and solar cells are used for power levels less than a few kilowatts. Larger power levels require either chemical propellant or nuclear mechanical-conversion systems. The chemical systems are best for short durations; nuclear systems are chosen for long duration and high power. (Papers 53R, 53S, 53T)

Cruise-Type Missile Propulsion—Vulnerability considerations dictate use of high-altitude, high-supersonic speed, and very-low altitude, high-subsonic-speed flight

profiles. Air-breathing engines, especially gas turbines, are best for these missiles. The most significant effects on engine performance occur in the induction and exhaust systems. (Paper 54R)

Unconventional Rocket Engines

—A wide variation in thrust chamber geometry is feasible. Possible geometries include: (1) spherical chamber, (2) throatless chamber, (3) diabatic chamber, or diverging reactor, (4) plug nozzle, and (5) spike nozzle—this type offers the greatest advantages. (Paper 54S)

Evaporative Cooling Problems

—Differential equations are used in designing evaporative cooling systems for hypersonic vehicles: (1) To find the optimum thickness of insulation so that the combined weights of insulation and evaporant will be a minimum. It is a function of the wall outer-surface temperature and compartment internal temperature throughout the flight. (2) To find the minimum required duct flow area—that which just produces choking at the required flow. Equations accounting for flow friction and heat transfer yield the choking length parameter. (Paper 54T)

Ramjets Can Be Smaller With

Pyrophoric Fuels—Pyrophoric fuels—which ignite spontaneously upon contact with the air—offer much promise of smaller, lighter ramjets for target drones. They may also simplify ignition of turbojet burners and afterburners. The three pyrophorics considered most promising are trimethyl aluminum (TMA), triethyl aluminum (TEA), and triethyl boron (TEB). (Paper 55R—see p. 70 of this issue)

Hydrocarbon Fuels for Supersonic Propulsion

—Hydrocarbon fuels are now the best practical alternative to liquid hydrogen for use in air-breathing supersonic aircraft, missiles, or high-thrust liquid rocket boosters. The polycyclic naphthenic type offers the best compromise of properties. Processed petroleum fractions—rich in these fuels—are competitive in quality, cheaper in cost, and more widely available than synthetic hydrocarbons prepared by chemical synthesis. (Paper 55S)

Solid Propellant Engines

—Solid engines can be developed up to the following, individually: (1)



Presentation of an award to Alan L. Morse (second from left) was a feature of the Meeting's luncheon on March 31.

The Award was the Laura Taber Barbour Award administered by the Flight Safety Foundation. The award was made to Morse, who is chief of the Aircraft Division of the Federal Aviation Agency's Technical Development Center at Indianapolis, for his "dedicated application to improvement of flight safety."

In this photograph taken just before the luncheon Jerome Lederer, managing director of the Flight Safety Foundation, Morse, and Frazer B. Wilde, chairman of the Barbour Award Board, are shown with Clifford E. Barbour, Sr. Barbour and his son, Clifford E. Barbour, Jr. are donors of the award, which honors the memory of Laura Taber Barbour, a victim of an air crash in 1945.

200,000-lb weight. (2) 4.5-million-lb thrust. (3) 60-ft length. (4) 96-in. diameter. (5) 90-sec duration. (6) 0.90 propellant (to total weight) fraction. (Paper 55T)

New Approaches to Fabrication — Continued current researches in the field of filamentary crystals or "whiskers" may lead to remarkable new advances . . . to evolution, among other things, of new approaches to fabrication techniques through which the astounding high strength of "whiskers" can be attained in bulk form. (Paper 56R — see p. 59 of this issue)

Refractory Nonmetals Tested — Tests by Bell Aircraft on ceramic and graphite materials for hot spot areas show that the best oxidation resistance at 2800 F was exhibited by a refractory body consisting of 90% silicon carbide and 10% boron carbide. Graphite coated with silicon carbide shows promise for applications at temperatures of at least 2800 F and possibly 3700 F for short periods. (Paper 56S — see p. 31 of this issue)

Brittleness Holds Back Moly — Molybdenum and its solid solution alloys form the vanguard of the refractory materials that will be used in advanced in-the-atmosphere and space vehicles. In its usable alloyed forms, however, it tends to be brittle at room temperature, suffering from a high brittle to ductile transition temperature. This limits its application at present to special areas of a vehicle or powerplant where either by design or handling, or both, the brittle characteristics of

the material will not be detrimental. (Paper 56T)

\$1.5 Billion for Ground Support Equipment — More than \$1.5 billion will be spent by the Department of Defense in fiscal 1960 for ground support equipment. Ground support equipment accounts for between 20% and 50% of the cost of an operational missile — depending upon the type. Thus, on the basis of cost alone, ground support equipment warrants a sustaining spotlight along with the airborne aspects of weapons systems. (Ground Support Equipment Panel — SP-327)

Government Terminology Revised — The words "lowest price" don't often appear in government contracts anymore. They have upgraded this to "fair and reasonable price" because low bidders often failed miserably on other phases of the contracts. (Make or Buy Panel — SP-327)

Numerical Control Pays for Itself — Numerical control machines at General Electric pay for themselves in 1-3 years. Positive jig borers are paid-up in one year. Lockheed Missile Division is said to be using 100% numerical control in the production of beryllium parts. Definition of tape control: a rolled-up template. (Numerical Controlled Machine Tools — SP-327)

Boeing 707 Suppressor-Reverser — An internal clamshell-type reverser is mounted between a 21-tube suppressor and the engine. The reverse cycle consists of driving the clamshell doors aft and blocking the exhaust flow. The

actuators for the clamshell doors are mounted on the top and bottom of the reverser frame. The airline pilots flying the 707 use the reversers on all landings. These units do not pitch the airplane, and brake replacement is much reduced. (Paper 57S)

Jet Noise Suppressors — The maximum sound pressure-levels of jets can be reduced up to 15 db. NASA tests show that the greatest sound power reductions and largest thrust loss were obtained with a lobed nozzle-ejector suppressor. To reduce the drag loss, the ejector could be retracted during cruise.

A rectangular nozzle noise suppressor, having an aspect ratio of 5, will achieve a 10 PNdb reduction in perceived noise level. This is on a constant altitude basis at 600-ft altitude and 70% of net take-off thrust. (Paper 57R, 57T)

Preventing Air Collisions — Cooperative collision-avoidance systems are under active investigation. But the long lead-time necessary for CAS development has resulted in the requirement for a self-sufficient proximity-warning indicator. The most desirable system would consist of a source and receiver operating at a wavelength in the far infrared. This device would combine the advantages of optical techniques for direction accuracy, and the transmission and efficiency advantages of microwave techniques. (Papers 58R and 58S. See p. 78 for more on paper no. 58R.)

Optimum Organization of Airspace — The following plan to organize United States airspace for air traffic control is proposed: (1) Establish a grid coordinate system for position indication. (2) Establish terminal zones. (3) Set up en route tracks between each set of terminal zones. (4) Establish en route control centers. (Paper 58T)

Storable Propellants — The basic trend in storable liquid propellants is directed toward combining high impulse with high-density impulse in low-freezing systems. Propellant research will provide storable liquid propellants with at least 10% higher specific impulses, and 20% higher density impulses, than currently available. (Paper 59R)

Cryogenic Propellant Problem — In a large cryogenic propellant system (using liquid oxygen), heat

transfer causes propellant loading problems. There can be large percentage errors when measuring the parameters used to calculate propellant load on board at launch. Insulating the tank decreases parameter error by yielding (1) Greatly reduced boiloff. (2) Nearly constant effective density. (3) Less violent surface conditions. (4) Virtual elimination of ice formation. (Paper 59S)

Thrust Control for Solid Propellants—Thrust magnitude in solid-propellant powerplants can be controlled by varying throat area. An accelerometer can relay messages to actuators which control the throat area. This would automatically compensate for variations in thrust, weight, and drag. Control of acceleration history would permit the use of a simple timer to signal cutoff, thus eliminating a complex computer to solve cutoff equations. (Paper 59T)

Jet Take-Off and Landing—Regulations SR-422, SR-422A, and in-process SR-422B deal with take-off and landing requirements, and minimum acceptable climb performance.

Jet aircraft problems include: (1) Lower coefficient of lift, due to thinner wing. (2) "Unsticking" or changing airplane attitude from that for optimum ground acceleration to optimum initial climb. Optimum rotation time is complicated because of differences in dimension and time which confront jet-transport pilots. (3) Obstacle clearance is more severe under new regulations. (4) Approach and landing speeds are higher and landing weights are greater. (5) Jet is more dependent upon wheel brakes.

Ways to improve take-off and landing characteristics include: (1) Installation of lead-edge, high-lift devices. (2) Retrofit or new purchase of aircraft powered by turbofan engines. (3) Use of boundary layer control actuated by turbine-discharge gas. (4) Use of direct-lift engines. (Papers 60R, 60S, 60T)

Manned versus Unmanned Systems—Manned military aerospace vehicles provide an increase in our airpower capabilities that is not achievable by unmanned systems. Also, aero-space vehicles for scientific research will make greater progress with a manned

system. Additional costs are present with manned vehicles, but increased capability per dollar makes them superior.

The relative desirability of manned aircraft and guided missiles in air defense depends on: (1) The tactical environment. (2) The performance characteristics of the weapon systems. (3) The political environment. (Papers 61R and 61S)

BOAC and the Comet 4—Experience with earlier jet transports was excellent preparation for the Comet 4. This aircraft started commercial operation with an engine overhaul life of 1000 hr. Part of the preparation for the Comet 4 included 3500 hr of flying Comet 2E's powered by two R.A. 29 engines and two earlier Avon models. (Paper 62R—see p. 63 of this issue)

Lockheed Electra—Eastern Air Lines' 23 Electras have demonstrated excellent flight characteristics, and exceeded specified performance. There are, however, several areas for improvement: (1) The present ground starting system is uneconomical. An APU for starting and all electrical requirements could be designed to operate only when landing gears are extended. (2) The electrical system components should be simplified, ruggedized, and protected against possibility of electrical fires. (3) Corrosion of compressor and turbine blading should be prevented. (Paper 62S)

American's 707 Experience—The main equipment problems with the 707 have been with electrical wiring and electronic equipment. Because of traffic control unknowns, full fuel capacity has been used more often than anticipated. Flights are carrying over 5000 lb more fuel than necessary. About 38% of February, and 15% of March westbound flights carried full fuel load. (Paper 62T)

Interplanetary Nuclear Rockets—For similar payloads, the power required by a booster nuclear rocket is 10^3 times that for a nuclear space rocket with an initial acceleration of $10^{-2}g$. For this reason, a space nuclear engine—boosted into orbit by chemical boosters—should be built first. As experience is gained, higher-power reactors for use as second-stage systems could be built.

Finally, the development of a high-power (up to 10^5 mw), high-temperature rocket capable of boosting a 500,000-lb payload should be undertaken. (Paper 63R)

Electric Propulsion Systems—In the nuclear turboelectric system for space propulsion, energy is generated outside of the electric rocket, and then added to the propellant. Electric rocket thrust is generally a few pounds. The propellant flow is several pounds a day; however, the exhaust velocity is 100,000 fps. And obtainable acceleration is 10^{-3} that of gravity. Therefore, this powerplant cannot be used to accelerate masses through strong gravitational fields near the surface of planets. (Paper 63S)

Plasma Acceleration—Preliminary studies have been made of plasma acceleration for propulsion. Results indicate: (1) The effective resistance of the gaseous conductor should be as large as possible, and minimize external circuit resistance, so that most capacitor energy is in the plasma. The addition of a magnetic field coupling will increase this factor. (2) The overall efficiency is small. Large losses in the charging resistor and discharge-circuit external resistance are areas for engineering attention. (Paper 63T)

VTOL Propulsion—The most important measure of a VTOL powerplant is its thrust-to-weight ratio for the take-off period. Special short-time (2 min) take-off ratings, and optimizing of the engine for a hot day (90 F), are urged. Compressor inlet water injection should receive more attention.

At each extreme of VTOL speed range, choice of a powerplant almost fixes itself. Very low speeds demand low-speed jet fans (helicopters). In high-speed aircraft, the propulsion powerplant (with means for thrust augmentation) is used for take-off. Between the extremes, propeller-driven VTOL's with multiple gas turbines having wide speed range are used. Final decision is influenced by the speed range desired, and whether military or civil use is envisioned. For example, civil VTOL requires a low noise-level, and low jet-velocity powerplants would be used for lower noise-levels. (Papers 64R, 64S, and 64T)

SAE Summer Meeting

... to be port of entry for European automotive engineering information.

PROBABLE economic consequences of the common market on the motor car industry of Western Europe will be the subject of one of the overseas sessions scheduled at SAE Summer Meeting, in Atlantic City, June 14-19. Additional European technical presentations will deal with description of some of the automation equipment employed in manufacturing facilities and a review of the European viewpoint on several common problems related to fuels and lubricant quality.

Among highlights of the American technical information is the session **SAFETY EVERY MOTORIST GETS** in which 16 engineers in the automobile industry have cooperated to bring together significant facts pertaining to

proved by additives or if a new type oil is needed.

- Methods of measuring loaded seats, headroom, and fatigue will be the subject of a panel **DEVELOPMENT OF SEATING FOR PASSENGER CARS**.

- A series of papers dealing with **ENGINE AND SPEED GOVERNORS** in which fleet operators needs and engine-vehicle manufactures requirements are compared with the results obtained from units available and planned for the future.

- Manufactures and users will discuss applications and techniques of using the latest adhesive materials at the **AUTOMOTIVE ADHESIVES** session. The discussion will point out the increased use of these materials as fastening devices in automobile construction.

- Engineers will obtain information on how preliminary evaluation of new plastic materials for automobile products can be undertaken at the **OUTSTANDING NEW NON-METALLIC MATERIAL** discussion.

- A **DIESEL ENGINE DEVELOPMENT STORY** will highlight some of the problems encountered in actual development of two new open-chamber diesel engines.

- Emphasis will be placed on light transmittance, optical properties, strength requirements, driver vision, and other vital problems associated with the increased use of glass in automobile construction at the **GLAZING MATERIALS** panel.

- Development of performance evaluation techniques for fuels and oils, using a 12-engine facility, a battery of low cost dynameters, and a system of magnetic recording of operating variables will be the subject of papers at the session **OFF-THE-ROAD TESTING TO GIVE ROAD RESULTS**.

- Since engineers are frequently called upon to make decisions regarding material selection they will be interested in **A REVIEW OF METALLURGY FOR ENGINEERS**.

- Additional sessions programed will deal with **RATING TRUCK TRANSMISSIONS**, various types of abnormal combustion resulting in **ENGINE NOISE**, **RADIOTRACERS MEASURE ENGINE WEAR**, a discussion of cooling system components at **UNDERCOOLING — NOT OVERHEATING**, and

TRENDS IN TRUCK AND BUS ELECTRICAL EQUIPMENT.

Several sessions of broad general interest will be scheduled throughout the week. Among those arranged are:

- **MILITARY GROUND TRANSPORTATION SYSTEMS** that will review the research and development considerations of the Army in determining its transportation needs to move on the earth's surface and immediately above it.

- **Secrets of modern nuclear physics** were unlocked about 25 years ago by the invention of particulators. An explanation of these instruments and review of the current state of the art in this frontier region of science will be discussed and illustrated at the **NEW PARTICLE ACCELERATORS** session.

- At one time U. S. cars were smaller than European cars. Who buys today's smaller cars? What is the market for new smaller automobiles as a second car? What effect will smaller U. S. cars have on the market for U. S. built larger cars? These and other questions will be discussed at the session **WHAT'S AHEAD FOR SMALLER CARS**.

- The **EARLY BIRD BREAKFAST** will explore methods of developing managers.

SAE



featuring progress in
GROUND VEHICLE ENGINEERING
in U.S. and Europe

work being done to insure safety in today's motor cars. The discussion will consider design factors, material selection, testing, quality control, reduction of driver fatigue, and durability of structural parts.

Papers and discussions of specific technical areas will include:

- Views of major companies supplying original equipment tires regarding many plans suggested for **SPARE TIRE ELIMINATION**.

- A **TWO-CYCLE ENGINE FUELS AND LUBRICANTS** session at which authors will discuss if utility engine cleanliness and performance can be im-

You'll ...

be interested to know that ...

An SAE member has just supplied concrete evidence of the pulling power of an SAE Placement ad. His letter says: "Your Service has put me in contact with 47 different prospective employers ... and has resulted in 23 interviews and 14 offers for employment. As soon as possible, I will advise you of my new employer. Please cancel my ad from the next Placement Bulletin."

There's a **NEW SAE STUDENT BRANCH AT ECOLE POLYTECHNIQUE**, University of Montreal's Engineering School, as a result of recent Council action. The new Branch starts off with 129 Enrolled Students ... and with Prof. Maurice Poupard as faculty representative.

With the granting of a charter to Ecole, SAE now has 57 Student Branches.

E. O. MARTINSON, Koehring Co., and **F. J. STERNAD**, Link-Belt Speeder Corp., are the latest additions to the personnel of the Farm Construction and Industrial Machinery Activity Committee.

Membership Approves Amendments to Constitution

Council Modifies By-Laws to Suit Amended Constitution

THE proposed Constitutional amendments, growing mainly out of the Planning for Progress proposal for the reorganization of the Society structure, were overwhelmingly approved by the nearly 5000 SAE members who voted. The Society's By-Laws also were modified by Council to reflect primarily the amended Constitution.

On March 19, the Tellers counted the ballots on the proposed amendments to the SAE Constitution which were submitted for letter ballot of the members on February 11, 1959. The Tellers report the following results.

There were 4999 ballots returned, of which 11 were void. Of the remaining 4988, 4879 approved the proposed revisions in their entirety. Proposed revisions in one or more sections were disapproved on the remaining 109 ballots returned. The approval votes received on each section are shown in the accompanying table.

The difference between the total number of ballots counted, 4988, and the approvals listed on each section represents the number of disapproval votes received on that section.

As stated in the Secretary's letter of February 11, transmitting the proposed amendments of the Constitution to the members for vote, the Constitution as revised goes into effect with the 1960 administrative year.

In addition to the changes in the By-Laws made necessary by the amendments to the Constitution, Council has approved a number of By-Laws changes to bring them up-to-date with current practices and to clarify them. For example, changes included in this category provide for the method of calling special business meetings, chang-

ing date of business meeting notices to comply with the law, eliminating need for witness on proxies, changing number of members to serve on Membership, Publication and Public Relations Committees to more adequately meet current needs, redefining duties of Publication Committee, providing for Board of Directors selection of

public accountant to audit books, changing deadline mailing date of ballot of election of officers to November 10 instead of October 20, to allow for printing of Nominating Committee reports in November Journal before mailing ballots.

A copy of the new Constitution and By-Laws will be sent to all members by the end of 1959.

Approval Votes on Each Section of the Constitution

C 2	4975	C 29	4970
C 3	4979	Deletion of current	
C 4	4980	section C 43 (follows	4959
C 6	4963	new section C 30)	
C 7	4971	C 31	4962
C 8	4969	C 32	4971
C 9	4971	C 33	4973
C 10	4971	C 34	4968
C 11	4972	C 35	4973
C 12	4972	C 36	4973
C 13	4971	C 37	4970
C 14	4974	C 38	4974
C 15	4977	C 39	4962
Deletion of current		C 42	4967
section C 12 (follows	4950	C 43	4970
new section C 15)		C 44	4971
C 17	4975	C 45	4961
C 18	4924	Deletion of current	
C 19	4970	section C 44 (follows	4958
C 20	4974	new section C 45)	
C 21	4974	C 46	4960
C 22	4978	C 47	4973
C 24	4978	C 48	4971
C 25	4970	C 49	4970
C 26	4970	C 50	4978
Deletion of current		C 52	4977
sections C 18 and	4963	Deletion of current	
C 19 (follow new	4963	sections C 28 and	4977
section C 26)		C 38 (follow new	4978
C 27	4963	section C 52)	
C 28	4969		

Caris and Nelson To Share Horning Award

GMC's Darl F. Caris and Edwin E. Nelson have been selected to share the 1958 Horning Memorial Award for their paper concerning the improvement of thermal efficiency in high-compression gasoline engines.

Caris' and Nelson's paper, "A New Look at High Compression Engines," was designated by the Horning Memorial Award Committee as the best paper relating to the mutual adaptation of internal-combustion engines and fuels.

The co-authors describe an investigation of the effect of compression ratio on engine efficiency over a range of compression ratios from 9/1 to 25/1. The results show that the thermal efficiency of the multicylinder engines used in this study peaked at a compression ratio of 17/1. The decrease in thermal efficiency at higher compression ratios is due primarily to delay in the completion of the combustion process.

Presentation of the paper was first made at SAE's 1958 Summer Meeting in June, and again at the National West Coast Meeting in August.

Caris, engineer-in-charge of GMC's power development engineering staff, joined GMC Research Laboratories in the electrical section in 1926. He became head of the Research Staff's automotive engines department in 1938, doing research on internal-combustion engine development, including two-stroke engines. During World War II, he worked on development of gyroscopic controls for Army Air Forces aircraft and in 1957 assumed his present responsibilities as engineer-in-charge of the Engineering Staff's power development section. His most recent work has been centered around development of modern high compression engines.

Nelson, also with GM's Engineering Staff, is currently project engineer in advanced engine development work. He received a Bachelors Degree in 1954 from The Ohio State University, and is now working toward a Masters Degree in Mechanical Engineering at Wayne State University. Nelson first joined General Motors in 1956, having served in the U. S. Army with the Transportation Research and Development Command at Fort Eustis, Va.

John G. Moxey, Jr., chairman of the Horning Memorial Award Board, will make the presentation during the 1959 Summer Meeting, in June, at Atlantic City, N. J.



Caris



Nelson

SAE National Meetings

- June 14-19
Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.
- August 10-13
International West Coast Meeting, Hotel Georgia, Vancouver, B. C., Canada
- September 14-17
National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.
- October 5-10
National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.
- October 26-28
National Transportation Meeting, La Salle Hotel, Chicago, Ill.
- October 27-28
National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.
- October 28-30
National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

Steel and Aluminum Serve Rocket Engines

Based on paper by

DONALD E. RODA

Rocketdyne Division,
North American Aviation, Inc.

SOLVING thermal-expansion and low-temperature problems for rocket engines has proved that steel and aluminum can be used instead of exotic materials.

Differential thermal expansion is a problem met, for example, with the bolts that hold together the volute of the liquid oxygen pump casting and hold the vanes in place. High strength bolts are required and their diameter is limited by the vane thickness. The greater contraction of the aluminum alloy casting causes it to shrink away from the bolts (which are approximately 3 in. long), leaving the bolts loose or completely without their torqued prestress load. Good low-temperature strength and toughness together with a high thermal coefficient of expansion are requisites of the materials used for these bolts. The material A-286 heat-treated to an ultimate strength of 145,000 psi, with a coefficient of expansion of 8.3 as compared to aluminum's 10.5, is better than heat-treated Inconel X with an ultimate strength of 175,000 psi and a coefficient of 5.7, provided there is an appreciable length of material.

Meeting Low-Temperature Problems

Low temperature mechanical properties constitute another problem. In this connection, types 410 and 440C stainless steels are attractive because of their better corrosion resistance and high strength in the heat-treated condition. They have been used successfully for parts which have no sharp corners or stress raisers and are not subject to impact loads. One example is the shaft for the gate of the main oxidizer (liquid oxygen) valve. The martensitic materials in the heat-treated condition are subject to a low-temperature transition from ductile to brittle type of failure. Just what the low-temperature mechanical properties of these materials are at -320 F (liquid nitrogen testing temperature) has not been known, so tests were made to determine them.

Fig. 1 shows the large increase in ultimate yield strengths from room temperature (white area) to low temperature -320 F (black area) for the 400-series stainless steels in the heat-treated condition. There is substantial reduction in elongation at low temperature with about 7% remaining for the 410 steel and 2% for the harder, stronger grade of 440C steel. These properties are required for efficient design and accurate stress analyses.

To Order Paper No. 4R . . .
on which this article is based, see p. 6.

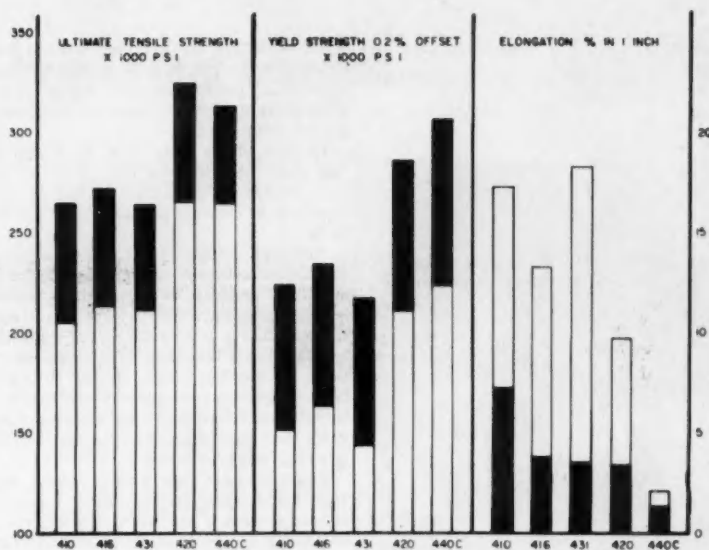


Fig. 1—Room-temperature and low-temperature (-320 F) mechanical properties of several 400-series stainless steels hardened and tempered.

Radioactive Tracers Aid Rubber Research

Based on paper by **S. D. GEHMAN**

Research Division, Goodyear Tire & Rubber Co.

BECAUSE of the importance of sulfur in rubber chemistry, the beta-ray-emitting isotope sulfur-35 has been especially useful in extending the unique advantages of tracer methods and techniques to rubber research.

Problems connected with the solubility of sulfur or sulfur-containing compounds in rubber mixtures, migration, and "blooming" or surface crystallizing tendencies can all be most readily investigated in the laboratory by means of radioactive sulfur.

The use of tagged sulfur in an unvulcanized rubber mixture is the basis for a very convenient laboratory method for determining the amount of sulfur which combines chemically with the rubber during vulcanization. Tagged sulfur and sulfur compounds have been employed to provide new information for interpreting the complicated chemical reaction mechanisms involved in rubber vulcanization and to characterize the type of sulfur-rubber compounds which are formed.

Extensive Russian publications in this field have emphasized the applicability of isotope exchange reactions for studying vulcanization.

Carbon-14 tagging has been used for

diffusivity measurements to investigate the segmental motions and internal frictional forces for rubber molecules. But the use of carbon-14 in rubber research has been much more limited than that of sulfur-35 and the potentialities for securing new and useful information through tagging with carbon-14 have by no means been fully realized.

To Order Paper No. 8R . . .
on which this article is based, see p. 6.

SAE Section Meetings

BALTIMORE

June 13 . . . Dinner-Dance. Gibson Island Yacht Club, Gibson Island, Maryland. Dinner 7:00 p.m.

NEW ENGLAND

June 1 . . . Annual Outing. Woodland Country Club, 1897 Washington St., Newton, Mass.

SPOKANE-INTERMOUNTAIN

June 6 . . . Annual Dinner-Dance. B.O.F. Club, Spokane, Wash. Cocktail Hour 6:30 p.m. Dinner 8:00 p.m. Special Feature: Introduction of new officers.

VIRGINIA

May 25 . . . Ladies Night. William Byrd Hotel, Richmond, Va. Dinner 6:30 p.m.

Brake Drums Need New Materials or Design

Based on paper by
V. A. CROSBY
Climax Molybdenum Co.

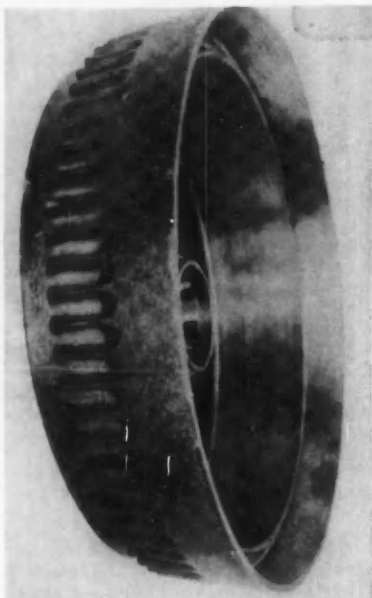


Fig. 1—Gray iron, flared-rim brake drum.

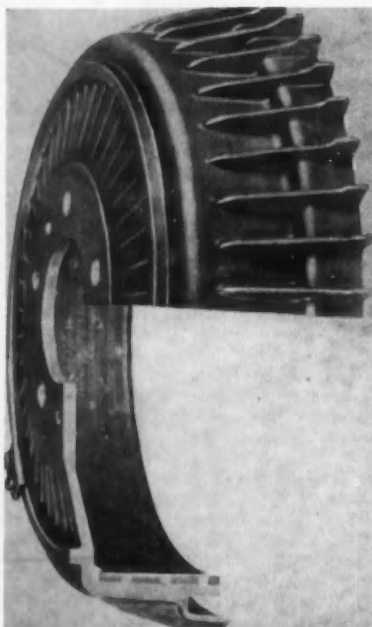


Fig. 2—Bimetallic brake drum uses aluminum as drum material and cast iron inserts as the braking surface.

THE TREND to smaller wheels and higher vehicle speeds suggests that improved passenger-car brake drum materials or design may be necessary in the near future.

Drums using gray iron in a flared-rim type of construction (Fig. 1) are one design possibility. Greater dissipation of heat is claimed for this design.

Another design possibility is a bimetallic construction using aluminum as the drum material and cast iron inserts as the braking surface (Fig. 2). Aluminum has a high rate of conductivity and a high capacity for dissipating heat to the air. But, so far it hasn't been effective as a wear-resistant material, and therefore some material like gray cast iron must be inserted for the braking contact.

Sprayed coatings which would provide good conductivity, good wear resistance, and a sufficiently high melting point to resist scoring and scuffing appear worthy of investigation for brake application.

The water-cooled brake represents still another interesting possibility. This type brake eliminates heat build-up, regardless of the number of high-speed stops, making it impossible for the brake to fade. Heat dissipation is accomplished by channeling liquid from the engine cooling system through tunnels in a copper lining. The lining is fused to a variation of the conventional brake shoe and contacts a conventional brake drum lined with a special friction material.

▲ To Order Paper No. 14S . . . on which this article is based, see p. 6.

Here's Where We Are On Fuel Specific Impulse

Based on talk by

WARREN E. WOODS

Continental Oil Co.

(Presented before SAE Wichita Section)

SPECIFIC impulse, which is the pounds of thrust obtained from burning one pound of propellant per second, is the controlling factor on rockets.

In 1942, we had a specific impulse of around 200, which gave a theoretical horizontal range of around 1300 miles,¹ with propellants taken from German experience, such as nitric acid as an oxidizer and alcohol fuel. By 1956, the figure had been raised to about 250 (giving a range of about 2500 miles¹),

¹ Values apply to a single-stage rocket with a 10/1 ratio; that is, the rocket weighs 10 times as much at take-off as at burnout.

using liquid oxygen in jet fuel. In 1958 the value had reached 300 (giving a 4750-mile¹ range) with liquid oxygen and dimethyl hydrazine.

The likely limit in the foreseeable future is around 340, which will probably be achieved with liquid fluorine as an oxidizer and hydrazine as a fuel. Both of these ingredients are difficult but not impossible to handle. The theoretical limit is around 375, with fluorine and hydrogen. It is doubtful that this limit will ever be achieved because of difficulties in hydrogen liquefaction. (A specific impulse of 400 is needed to place the empty rocket in satellite orbit. With a value of 500, such a rocket could reach escape velocity and escape from the earth's gravitational field.)

There are, of course, a number of Buck Roger possibilities. For example, using an atomic pile as a source of heat and hydrogen as a working fluid. This would give a specific impulse of about 900. Recombination of isolated free radicals might give up to 1800. For outer space work it is conceivable that we might get to 20,000, using a cesium ion beam produced by a reactor in space. These latter possibilities are not outside the realm of probability. In fact, all three are being actively explored under government auspices. Nevertheless, for the next few years—and maybe longer—we will continue to use normal chemical combustion fuels.

How Vulcanization Changes Rubber Structure

Based on paper by

S. D. GEHMAN

Research Division, Goodyear Tire & Rubber Co.

A RUBBERY material is composed of long, entangled, thread-like molecules, as illustrated in Fig. 1. Each long polymer molecule consists of thousands of small, repeating units or monomer units, which are joined in more or less regular fashion to form the backbone of the polymer molecule. There may be various branches and groups of atoms on the main chain. The chemical composition of the molecules may vary widely, since the only essential feature for rubber-like elasticity is that the molecules be long and flexible and that there be a temperature range in which the intermolecular forces are sufficiently weak to permit the molecules to "coil-up" and assume random configurations due to the thermal jostling of their segments.

The molecular entanglements provide some strength, but they slip and yield under stress, so that unvulcanized rubber is thermoplastic and can be mixed

SAE Tractor Test Code Now Covers Crawlers

THE SAE Agricultural Tractor Test Code owes its greatly improved content to the Tractor Test Code Subcommittee of the Tractor Technical Committee. By working closely with the Nebraska Test Board (which acts as a certification agency for farm tractors for the State), Subcommittee members reshaped the Society's basic farm tractor testing document as follows:

- The code now covers crawler as well as wheel-type tractors.
- Drawbar hitch-point height has been limited by means of a new formula.
- A single fuel setting has been established which enables one test procedure to be applied to tractors having diesel or carbureted engines. Previously, in some cases, an additional test was required for the latter.
- Only one governor setting is called for (except when a manufacturer specifies different governed speeds for power outlet and drawbar operation). Thus, the old Rated Power Run Test has been dropped.
- A drawbar run, formerly made

without ballast and with the smallest-sized tires and wheels available, was also dropped.

Belt Pulleys Disappearing

The rapidly disappearing belt pulley and increasing horsepower trend led to radical changes in the Rated Power—Ten Hour Run Test. Now known as the Varying Drawbar Power—Fuel Consumption Run, the test calls for fuel consumption runs to be made with the tractor operating as follows:

- (a) Maximum available power.
- (b) At 75% of the drawbar pull obtained at maximum power.
- (c) At 50% of the drawbar pull obtained at maximum power.
- (d) At the manufacturer's rated drawbar-power output when his rating does not correspond to the power output of either run 1 or 2.

The advantages of the above are:

In cases where a manufacturer does not equip the tractor with a power outlet, varying power fuel consumption runs can be made on the drawbar. Likewise,

if the dynamometer equipment is not large enough to handle the tractor power, varying power fuel consumption runs can be made on the drawbar.

The present code provides for the proper testing of the following transmission types:

- Conventional selective gear transmission.
- The transmission equipped with a torque converter.
- The automatic power-shifting fixed-ratio transmission.
- The operator-controlled power-shifting fixed-ratio transmission.
- The infinitely variable type transmission.

Slated for 1960 SAE Handbook

Subcommittee Chairman Raymon Bowers reports that revised Agricultural Tractor Test Code will be included in the 1960 SAE Handbook when it is issued next January.

with other ingredients and molded or calendered.

Vulcanization consists in the introduction of chemical cross-links at random points along the molecules. These cross-links stabilize the network mechanically so that the plasticity of the raw rubber is suppressed and it displays characteristic rubber-like elasticity. A large diversity is possible in the chemical nature of cross-links which will accomplish this conversion

from the plastic to the elastic condition. The modulus and physical properties of the vulcanized rubber are sensitive to the number of cross-links. Relatively few cross-links, less than one cross-link per hundred of monomer units along a chain molecule, are required to produce well-vulcanized rubber.

Chemical vulcanizing agents are mechanically mixed with the raw rubber and the cross-links are formed as a consequence of chemical reactions brought about at the elevated temperatures used in the vulcanizing process. Other materials, especially reinforcing fillers such as carbon black, are also usually incorporated to secure desirable properties. A simple type of tire tread formulation is given in Table 1.

Sulfur and sulfur compounds, although by no means indispensable for vulcanization, have been by far the most important vulcanizing agents since the original discovery of vulcanization by Charles Goodyear. The chemical reactions that occur during vulcanization are very complex. In spite of the fact that the process has

been known for nearly 150 years and several million tons of rubber are vulcanized annually, it is still impossible to write down an indisputable reaction or series of reactions to describe the process and the product. The coincidence that sulfur is a key element in vulcanization and that it has a very suitable radioactive isotope for tracer experiments has led to many interesting tracer studies of vulcanization reactions.

To Order Paper No. 8R . . .
on which this article is based, see p. 6.

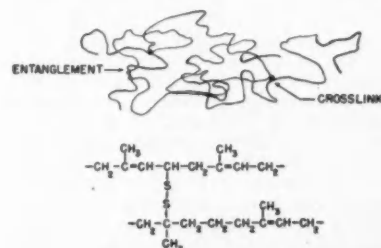


Fig. 1—Representation of rubber structure.

Table 1—Tire Tread Mixture

	Parts by Usual Weight Range	
Rubber	100	100
Zinc Oxide	5.0	2-5
Sulfur	2.0	1-3
Mercaptobenzothiazole	.75	.5-1
Stearic Acid	2.0	1-5
Antioxidant	1.0	1-2
Carbon Black	50.0	40-50
Vulcanization: 45 min at 295 F		

Reactors May Supply Process Heating—Some Day

A report of the
SAE Nuclear Energy
Advisory Committee

NUCLEAR reactors may some day be used as the source of heat for high-temperature heat and low-pressure steam. Both of these industrial processes consume very large quantities of energy:

- High-temperature heat for such things as pyrometallurgical processes and chemical reactions requiring elevated temperatures.

- Low-pressure steam for such processes as the drying of bulk chemicals.

High-Temperature Heat

If a cheap source of high-temperature heat were available, it could be useful in many ways. It could reform methane to hydrogen, it could be used in various metallurgical processes, and for the fixation of nitrogen. The temperatures required range, in general, from 2000 to 4000 F. This, in turn, necessitates fuel elements capable of operating in this range. Unfortunately, satisfactory elements of this kind have not yet been developed. It is, therefore, difficult to assess with any degree of accuracy what the ultimate potentialities are. Use of reactors as a source of such high-temperature heat must, therefore, be regarded only as an interesting possibility until more data are available . . . and this may be well in the future.

Low-Pressure Steam

The situation on low-pressure steam is quite different. Here the technology is already established and no serious difficulties appear. It is essentially a question of economics. Since the cost of generating steam now varies widely, depending on location and the availability of fuel, there clearly is no single answer of broad validity.

Rough estimates can be made, however. A medium-sized reactor using uranium of low enrichment would seem to be feasible for this purpose. Such uranium would be leased from the AEC. After the fuel has been partially burned, it must be removed and chemically processed to remove fission products and to recover unconsumed uranium 235 and plutonium. These recovered products are then purchased, by prior agreement, by the AEC.

All this makes the calculation of fuel costs rather complex, so that it is difficult to forecast just what the cost of

steam will be. It is fairly evident, however, that it would be higher than the present cost of steam in most locations of the United States. The more optimistic estimates still leave about a 10% cost penalty, even in areas where present fuel costs are high. This increased cost is due primarily to the large initial investment required of a nuclear reactor; actual operating costs of a reactor are expected to be competitive with those of fossil-fuel-fired plants. Much of the high initial investment now required is due to ignorance and lack of experience with nuclear reactors.

Since complete operating data are not available, the nuclear reactor at present is almost always overdesigned with factors of safety higher than would probably be necessary if more exact information were available. As such information is accumulated, the current economic disadvantage of nuclear heated plants should tend to disappear. The time schedule for this process is still the subject of much controversy, and time-wise extrapolation of current trends is still highly unreliable.

Goodrich Develops New Earthmover Brake

Based on paper by

P. A. SMITH

and

P. F. BLACK

B. F. Goodrich Aviation Products

A MULTIPLE-SHOE high-torque brake which features fast stopping coupled with low drum temperature is being produced by B. F. Goodrich Aviation Products.

To insure effective contact of the lining with the drum without deformation, each block has a length approximating its width. There are no rigid connections between the lining and the actuation to impair radial movement. Each lining is constrained from axial movement by side frames and from rotational movement by torque bars. Extending through the side frames and lining is a leaf spring, which applies a force to the linings toward the center of the brake for purpose of prompt retraction.

The torque developed by each lining is opposed by torque bars welded into

the side frames, and both torque bars and lining elements are placed evenly about the 360-deg brake circumference. Actuation is by a full circle, hydraulic expander tube made of fabric-reinforced neoprene. This tube imparts direct and equal pressure to all linings.

Comparative tests were run with a 4-wheel, M-R-S 250 tractor pulling a 4-wheel Wooldridge OS-300 scraper, fitted with Hi-Torque brakes on the rear tractor axle and rear scraper axle, and a similar unit fitted with conventional brakes. With scrapers loaded, the gvw was in excess of 106 tons. The unit with the Hi-Torque brake recorded a stopping distance 58% of that required by the combination with conventional brakes.

When dynamometer tests were run at a constant drum speed of 53 rpm, and brakes were applied and released in cycles of 15 sec on and 15 sec off, the Hi-Torque brake could absorb 64% more work over the same time interval per deg drum temperature rise than the conventional type.

To Order Paper No. 265 . . .
on which this article is based, see p. 6.

Use New Ideas To Cut Maintenance

Based on paper by

M. K. SIMKINS

Commercial Car Journal

(Presented before SAE Metropolitan Section)

THE squeeze is on. Management says "streamline or show cause . . ." and the fleet superintendents are sitting right out on a bare limb. The superintendent has sat back for a long time doing what comes naturally. He has built himself a little empire in the maintenance department and sometimes he has closed the doors on any new ideas.

Every year brings forth new products designed to aid fleet maintenance. The fleet man should watch for these with an eye to selecting those which promise to cut his costs. Moreover, to make an intelligent selection of parts and supplies, he should run a controlled test program to give these new products a field test under normal fleet operating conditions. Most fleets are running such tests but much more remains to be done along this line by many operators.

The important thing in applying new principles to fleet operation is the open mind with which they are tried and proved or disproved. Take the matter of farming out certain jobs where work volume does not justify purchase of

Continued on p. 114

About SAE Members

F. EMIL SANDBERG, executive engineer, truck product engineering, Ford Division of Ford Motor Co., retired on April 1 after nearly 34 years of service. Sandberg joined Ford in May 1925 as a machinist at the Highland Park Plant. He worked his way up to chief truck engineer in July, 1953 and was named executive engineer, commercial vehicles office in October, 1953. He served in that post until being named to his present position in October, 1956. Sandberg, who has been a member of SAE Overseas Information Advisory Committee, plans to keep abreast of the trucking industry and will continue to keep informed of SAE Activities. Sandberg lives at 17366 Melrose Drive, Detroit.

BABOO RAM TERE has been made vice-president—engineering of Republic Manufacturing Co. Prior to this, he was vice-president—engineering and manufacturing for Greer Hydraulics, Inc. Tere is chairman of SAE Committee A-6 (Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment) and is a member of SAE Aircraft Activity Committee.

CARL J. DEMRICK has been named president of Amplex Division, Chrysler Corp. Prior to this, he was vice-president in charge of manufacturing for Plymouth Division of Chrysler. Demrick succeeds **G. W. TRICHEL**, who will take on new responsibilities as military advisor to the group vice-president—defense and special products.

ROBERT J. TEMPLIN has become staff engineer with Cadillac Motor Car Division of General Motors Corp. He will be in charge of future mechanical developments. Since 1957, Templin has been on special assignment for Cadillac in Detroit.

ELI R. LUPIN has been made assistant chief engineer, Hydraulic Division of J. I. Case Co. Prior to this, he was chief engineer for Sherman Products, Inc.

HARRY KOTTAS has become chief product engineer of commercial products at the South Bend Division of Curtiss-Wright Corp. Formerly, he was assistant director of engineering for AK Division, Avco Mfg. Corp.



Sandberg



Tere



Demrick



Templin



Lupin



Kottas



Mandy



Baum



Boehm



Lloyd

ROBERT R. MANDY, president of Diversified Engineering Laboratories, has been elected to the board of directors of Delman Co.

HARRY BAUM forms a new technical publicity agency, Harry Baum Associates in New York City. The new agency offers complete technical publicity services and specializes in the preparation of company-sponsored engineering handbooks. He was formerly a project manager for McGraw-Hill technical writing service and style editor for McGraw-Hill Encyclopedia of Science and Technology.

ERIC G. BOEHM is now general manager of Buffalo Bolt Co., a division of Buffalo Eclipse Corp. He was formerly assistant general manager for the same company.

WILLIAM T. LLOYD has been named to represent the Automotive Division of Clark Equipment Co. in the southeast states. He is also manufacturer's representative for Chelsea Products, Inc.

Ford engineering executives **VICTOR G. RAVIOLO** and **PHILIP H. PRETZ** have made personal investments in Great Lakes Air motive, Inc. They are board members and vice presidents of the company, which is a fixed-base operation at Willow Run Airport. The company has a Cessna dealership and provides service and charter flights. Raviolo is special assistant to Ford vice-president Andrew Kucher; Pretz is director of Ford's Testing Operations. Pretz was 1958 SAE vice-president representing Passenger Car Activity.

JOHN F. KUNC has been named senior research associate of Esso Research and Engineering Co. The position is awarded to scientists and engineers with outstanding technical abilities. Kunc, a member of the firm's products research division, is in charge of the division's exploratory activity focused on long-range research work on fuels and the application of nuclear radiation to product quality problems. Kunc was SAE 1955 vice-president representing Fuels and Lubricants Activity.

CARL M. CHRISTENSON, assistant vice-president—flight operations, United Air Lines, Inc., has been made



Young

VINCENT C. YOUNG has retired as chief engineer of the Valve Division of Eaton Mfg. Co. He will continue in a consulting capacity and will be available for consultation and assistance on special problems. **LOUIS J. DANIS**, chief product engineer of the Valve Division, together with **LAWRENCE F. JENKINS**, product engineer, and **CARLETON H. SWANSON**, engineering manager, will be responsible for all Valve Division engineering activities.



Danis

a member of the research advisory committee of the National Aeronautics and Space Administration. He has been 1958 SAE vice-president representing Air Transport Activity.

ERVIN N. HATCH, Nassau (N. Y.) County's director of franchises, returned recently from Caracas. He assisted Col. Sidney H. Bingham (former chairman of the Board of Transportation of the City of New York) who was requested by the Government of Venezuela to make a study of the entire transportation requirements of the City of Caracas.

GLENN S. BEIDLER is now senior designer with National Water Lift, Division of Cleveland Pneumatic Industries. Formerly, he was structural design engineer for Missile Division, Chrysler Corp.

MAURICE T. MOLER has been made president and treasurer of Bryant Clamp Corp. Prior to this, he was sales manager for United Specialties Co.

JOHN F. CREAMER, JR., vice-president of Wheels, Inc., was a first place winner in the 1959 Convention Essay Contest of Motor and Equipment Wholesalers Association's young executives group. Creamer's essay was "A Product Selection Formula, or How We Select a New Line."

A. P. FONTAINE has been made an engineering vice-president of Bendix Aviation Corp. Since 1955, he was a vice-president for Bendix.

PERRY W. HOUSE has been made manufacturing manager at Anderson plants, Delco-Remy Division, General Motors Corp. He will report to **H. G. RIGGS**, works manager. Formerly, he was assistant chief engineer for Delco-Remy.

JOHN D. BAKER has been made assistant chief engineer with Delco-Remy Division, General Motors Corp. He will report to **H. L. HARTZELL**, chief engineer. Formerly, he was assistant general sales manager of Delco-Remy.

ROSS S. KARLSON has been named service sales representative at American Bosch Division, American Bosch Arma Corp. He will represent American Bosch in Denver, El Paso, and Phoenix. Formerly, he was section supervisor, mechanical laboratory for American Bosch.

JOHN Y. H. AHN has been made assistant chief, maintenance and storage branch with the U. S. Army. Prior to this, he was production specialist, quartermaster items, for the U. S. Army.

FORREST A. STINSON has been made assistant general sales manager with original equipment, Delco-Remy Division of General Motors Corp. Formerly, he was regional sales manager for Delco-Remy.

R. C. ROBERTSON has been made chief production engineer with Delco-Remy Division, General Motors Corp. He will report to **H. G. RIGGS**, works manager. Formerly, he was superintendent of plant 7 for Delco-Remy.

R. W. COCHRAN is now president and general manager of Truck Equipment Co. of Arizona. Prior to this, he was branch manager for White Motor Co.

ALBERT M. LANE has been named commercial markets development manager at Vickers, Inc. He will direct exploration and development of hydraulic applications in areas not presently served by Vickers. Formerly, he was general sales manager, Mobile Hydraulics Division for Vickers.

HOWARD KETCHAM has written a guide to constructive and profitable color planning. Written for the businessman in every field who wants to know how to add the impulse sales appeal of color to his product, the book is titled "Color Planning for Business and Industry" and was published by Harper & Brothers. It is available at \$5.95. Ketcham explains how color operates to enhance product appeal, how it can increase employee satisfaction and production in the factory and office, and how it serves advertising, direct mail sales, packaging, and display. He also includes chapters on color in facial make-up, clothing, and interior decoration. The book is illustrated with 8 pages of full color photographs.

CLEAF A. BEST has been made senior development engineer on the technical staff of Denver Laboratories, Ramo-Wooldridge, a division of Thompson Ramo Wooldridge, Inc. Formerly, he was chief development engineer for Sparton Automotive Division, Sparks-Withington Co.

JAMES R. HASTINGS has been made central region manager of Bendix-Westinghouse Automotive Air Brake Co. Prior to this, he was assistant regional manager for Bendix-Westinghouse.

MICHAEL FERENCE, JR., director of engineering staff, Ford Motor Co., has been made a member of a Special Advisory Committee to the U. S. Department of Commerce. They plan to study the scientific programs of the department and to recommend new steps to gear them to the rapidly changing needs of science and industry.

NELSON E. FARLEY has been made director of Chevrolet operations at General Motors Proving Ground, General Motors Corp. Formerly, he was director of the engineering laboratory, Chevrolet Motor Division, GMC.

HOWARD H. KEHRL succeeds Farley as director of the engineering laboratory, Chevrolet Motor Division of General Motors Corp. Formerly, he was assistant laboratory director.

RUSSELL B. DEEDS is now a sales representative with Panther Oil and Grease Mfg. Co. Formerly, he was an automotive advisor for U. S. Atomic Energy Commission.

ARTHUR F. PELSTER has been made vice-president of Avtron Mfg. Inc. Prior to this, he was vice-president of sales for Leland Electric Co.

DARIO R. GROSS is now an investigations engineer with Cummins Engine Co. Prior to this, he was design engineer, trainee for Cummins.

KENNETH L. SELBY has become vice-president and general manager of Transportation Products Division, National Malleable and Steel Castings Co. Formerly, he was vice-president of engineering for the same company.

ANGELO R. DeVITO has become project engineer, Research Division of Atwood Vacuum Machine Co. Prior to this, he was development and design engineer for the same company.

ARNOLD A. DACH is now chief plant engineer, Eastern Division of Sealtest Foods a division of National Dairy Products Corp. Formerly, he was transportation manager for Chestnut Farms Division.

ROBERT W. SEWALL has become an electrical engineer at Allison Division, General Motors Corp. Prior to this, he was a specialist 4th class for the U. S. Army at the Pine Bluff, Ark., Chemical Arsenal.

R. W. HOWELL is now plant manager of Highway Trailer Co. He was formerly assistant to the vice-president and general manager for Rheem Auto Co., a division of Rheem Mfg. Co.

BERNHARD H. KNELL has been made field application engineer with Cummins Engine Co., Inc. in Zurich, Switzerland. Formerly, he was design engineer for Cummins.

HENRY E. J. PRINGHAM is now principal design engineer at Ford Motor Co. Prior to this, he was chief project engineer for the South Bend Division, Curtiss-Wright Corp.

ROBERT E. STRASSER has become field engineer at Whittake Controls, a division of Telecomputing Corp. He was formerly customer relations representative for Fairchild Engine Division, Fairchild Engine and Airplane Corp.

RODGER E. HOLMSTROM has been made service parts manager at Kenworth Motor Truck Corp. Prior to this, he was parts manager for the same company in Colorado.

ROBERT E. COLEMAN has been made manager, West Coast office, Propeller Division of Curtiss-Wright Corp. Formerly, he was a sales engineer for Weatherhead Co.

JOHN J. FOX has become evaluation engineers aid at the Aeronautical Division, Minneapolis-Honeywell Regulator Co. He was formerly a student at Tri-State College.

CLINTON G. ROOD, JR., is now sales engineer with Gustafson Oil Co. Prior to this, he was a sales engineer for Refiners Petroleum Co.

Continued on page 110

Thompson Ramo Wooldridge Makes Executive Promotions

A. T. COLWELL has been appointed to the newly-created position of vice-president—engineering, research and development at the corporate staff level of Thompson Ramo Wooldridge, Inc. In support of TRW's over-all corporate policy to put increasing emphasis on non-military business, Colwell will devote much of his time to the non-military area.

In addition to the investigation of new products and companies dealing in new products, he will provide liaison and exchange useful information among the various TRW divisions, including also Pacific Semiconductors, Inc. and Thompson-Ramo-Wooldridge Products Co. Colwell has been chairman of SAE's Finance Committee since 1944 and was 1941 SAE president.



Colwell



Gibian



Thoren

EMIL F. GIBIAN has been appointed to the newly-created position of director of industrial engineering at the corporate staff level of Thompson Ramo Wooldridge, Inc. He will act as chief consultant on industrial engineering matters, including standards engineering, hourly job evaluation and wage surveys, budgetary controls, inventory control, methods and plant layout, statistical control techniques, architectural services, and mobilization planning. Gibian served in a similar capacity on the corporate staff of Thompson Products, Inc. before its merger with Ramo-Wooldridge.

In his new post he will continue to have responsibility for the control of government property in the possession of Thompson Divisions. Gibian has been 1952 SAE vice-president representing Production Activity.

T. R. THOREN has been made assistant to the vice-president and general manager of Ramo-Wooldridge Division, Thompson Ramo Wooldridge, Inc. Formerly, he was staff director, engineering, research and development for Thompson Products Division. Thoren is SAE councilor for 1959-1960 and was 1958 chairman of the Sections Committee.



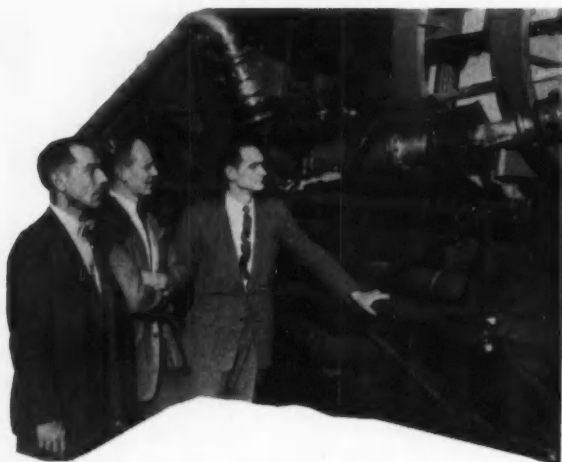
Noon

T. C. NOON has been made engineering manager of the entire Tapco Group, Thompson Ramo Wooldridge, Inc. He was formerly associate director, staff research and development, new devices, for Thompson Products Divisions.



Davidson, Jr.

A. J. DAVIDSON, JR., has been made manager of automotive development, automotive group of Thompson Products Divisions, Thompson Ramo Wooldridge, Inc. Formerly, he was associate director, staff research and development, automotive for Thompson Products Divisions.



INSPECTING the Thor Launcher — during a tour of the Food Machinery and Chemical Corp's Ordnance Division in San Jose — are three members of **NORTHERN CALIFORNIA SECTION'S SOUTH BAY DIVISION**: left, Vince Gilbert, South Bay Division chairman; center, Bill Miranda of the Division's Program Committee; and right, Meeting Speaker Duane Shaw, of the Rucker Co. of Oakland.

Shaw's paper, entitled "Hydraulics for Missile Handling and Erection," described the Polaris Erector. Prior to the meeting, engineers inspected both the Bomarc Launcher and the Thor Launcher.

A novel floating wobble-disc, mounted at its hub on four ball bearings to provide floating action, is one of the features on the new Holmes 2-stroke engine . . . described to **NORTHERN CALIFORNIA SECTION** in March.

With 16 cylinders of 261 cu in. displacement, 200 brake hp can be developed on gasoline with a specific fuel consumption of about 0.5 lb/bph/hr. This is accomplished at a speed of 3200 rpm and on 87 F-1 octane gasoline at 9.5 compression ratio.

Other features of the engine include rotary valves, and the use of the underside of the piston to compress the air charge for cylinder scavenging.

Inventor of the engine, Fred J. Holmes (left) discusses the crankcase with Ted Kressler (middle), chief tool engineer, Hughes Aircraft Co.; and E. C. Hussey (right), of Hussey Engineering Corp., who made the presentation.



Rambling . . .

THROUGH

Over 375 engineers attended **METROPOLITAN SECTION'S** special Section-wide meeting and banquet in March. Afternoon sessions for all activities were held, including turbo-charging of diesels, the new family of business airplanes, and crankcase oil drain periods . . . followed by the banquet featuring A. T. Colwell, SAE past-president and vice-president of Thompson Ramo-Wooldridge Inc.

Principals at the meeting were: (left to right) R. W. Hogan, general chairman of the meeting; R. M. Cokinda, Section past-chairman; S. G. Tilden, Jr., Section chairman; A. T. Colwell, who spoke on "Propulsion, Petroleum, and People"; and SAE President Leonard Raymond, making a presidential visit to his "home-town" Section.



Five separate motions of a lifting fork are special features of Clark Equipment Co.'s new military rough terrain fork truck. The arm-type loader mechanism was produced by Clark to meet specifications of the Army Quartermaster Corps . . . notable engineering features of the vehicle include an anti-spin differential, an industrial-type torque converter, an oversized power-plant (by commercial standards), and deep sump pump oil pan to allow operation on 45% grades. There are three modes of steering: 2-wheel, 4-wheel (radi-arc), and four wheel oblique (crabbing); open disc-type brakes; and 15 psi pressure tires.

Another engineering innovation encompassed in the Clark vehicle is a hydraulically controlled fork levelness maintenance (as opposed to other "parallelogram" type loading arm mechanisms), which is keyed by a "slave" cylinder.

Presentation was made by Cyril B. Rogers, manager of Clark's Development Division, and Jerome R. Susag, chief engineer, special products section, Clark's Industrial Truck

THE SECTIONS

Division, at **SOUTH BEND DIVISION, CHICAGO SECTION** in March.

Six students and an assistant professor from the University of Notre Dame were special guests at the meeting . . . (left to right around table) R. Sokolovske; L. Leach; T. Keegan; J. T. Von Lührte; Clark Development Engineer K. H. Mindrum; Clark Senior Project Engineer R. E. Greenman; Clark Chief Product Co-ordinator S. R. Skellenger; and J. Haggard. Messrs. Mindrum, Greenman, and Skellenger were hosts to the students for the evening meeting.



SOUTHERN CALIFORNIA SECTION members heard two specialists on reliability and quality assurance at their February meeting . . . left is Capt. Thomas C. McDermott, USAF, who presented a paper by E. J. Lancaster (staff assistant for Quality and Reliability Headquarters, Ballistic Missile Center A.M.C., USAF), on missile reliability from a production and logistics viewpoint; center is Harvey C. Christen, Section vice-chairman for Aeronautical Activity; and right, Clare W. Harris, director of quality assurance of Lockheed Missile and Space Division, who spoke on quality assurance for missile reliability.



SAE President Leonard Raymond (center) meets with **PITTSBURGH SECTION** Chairman A. E. Dible, (left) and SAE Past-President R. J. S. Pigott, (right).

Raymond spoke to the Section on "How Tomorrow's Problems Challenge Today's Research." Prior to the technical meeting, Raymond toured the Irwin Works of U. S. Steel Corp. with **Roger F. Mather**, and met with Pittsburgh Section Governing Board.



MID-MICHIGAN SECTION members met in Bay City at the March meeting and toured the Dow Chemical Co.'s magnesium foundry. They observed the casting, finishing, and testing of many magnesium components used for missile launching emplacement.

Following the tour, R. V. Lohmiller (left), of Bell Telephone Laboratories, addressed the group on the "Nike Hercules Missile." Appearing with Lohmiller are Elton William, commercial manager of the Saginaw Valley Area of Michigan Bell Telephone, and E. E. Otto, Mid-Michigan Section chairman.

Starting in 1866 to manufacture a horse-operated device which removed hay from wagon to barn, Sprout-Waldron & Co., Inc. of today has become a leading manufacturer of feed mill machinery through what they call "adaptioneering."

The company has expanded into various fields to produce mixing and blending equipment, size reduction machinery, bulk materials handling equipment, pellet and densifying mills, and many special products such as hoppers, tanks, rice tumblers, etc. All this by a company which employs only approximately 750 people, with an engineering staff of slightly over 60 people!

All phases of the company's operation were discussed at **WILLIAMSPORT GROUP** by Sprout-Waldron's vice-president in charge of engineering, H. Marshall Soars, Jr.

About SAE Members

(continued from page 107)

RICHARD S. KOONTZ is now a project engineer with Ordnance Development Division, Eureka-Williams Corp. He was formerly a project engineer for Brown Rubber Co.

GEORGE H. NELSON has been made a service instructor at Cummins Engine Co., Inc. Formerly, he was equipment engineer for Burlington Truck Lines, Inc.

HERBERT ERICKSON has become systems engineer at Crucible Steel Co. of America. Prior to this, he was methods and planning engineer for Westinghouse Electric Corp.

RICHARD J. BECHT is now Northeast district representative with Koehler Aircraft Products Co. Formerly, he was senior project engineer for Koehler.

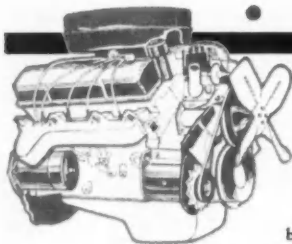
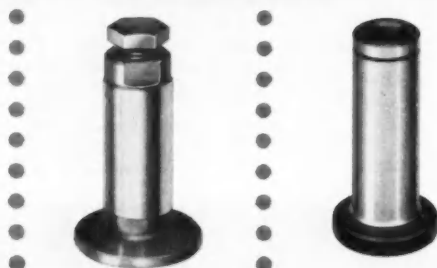
RALPH S. BENNETT is now national fleet sales representative at White Motor Co. Prior to this, he was fleet sales representative for GMC Truck and Coach Division, GMC.

Prof. W. H. PAUL, faculty advisor of the SAE student branch at Oregon State College, is touring Europe by car with Mrs. Paul. Their plans are to visit and study a number of automobile manufacturing plants.

MARCEL PIRY has been made project engineer at Republic Aviation Corp. Prior to this, he was chief preliminary design engineer for Fairchild Engine Division, Fairchild Engine and Airplane Corp.

JOHN L. LASS has been made mechanical engineer, Product Research Division of The Budd Co. He was formerly proof officer, Automotive Division for the U. S. Army Ordnance, Development and Proof Services.

JOHNSON tappets



**for all engine applications*

All of the engineering and manufacturing effort at Johnson Products goes into producing a better tappet. Continual experimentation and exacting quality control make JOHNSON TAPPETS worthy of your consideration. Only proven materials, covering a range of hardenable iron, steel, and chilled iron of various alloys, are used in JOHNSON TAPPETS. These tappets are successfully used in jobs ranging from light duty to the most severe, punishing applications. Serving all industry that employs internal combustion and diesel engines.



"tappets are our business"

JOHNSON  PRODUCTS
MUSKEGON, inc. MICHIGAN

Obituaries

O. L. ANDERSON . . . (M'24) . . . retired as group leader, engine design, Oldsmobile Division, General Motors Corp. . . . died December 29 . . . born 1893.

HENRY G. FALLERIUS . . . (M'17) . . . fleet manager for City Products Corp. . . . died November 23 . . . born 1891.

DAVID GREENHILL . . . (M'53) . . . equipment manager, G. M. Gest Ltd. . . . died January 15 . . . born 1912.

JEAN-LOUIS-EUGEN GROFF . . . (M'55) . . . professor, Scientific Advisor, Institut Francsis du Petrole in France . . . died February 23 . . . born 1893.

JESSE A. KINGSBURY . . . (M'18) . . . retired as head materials engineer for the Department of the Navy . . . died November 19 . . . born 1888.

CHARLES PORTER ROBERTS . . . (M'28) . . . professor of mechanical engineering at Ohio State University . . . died January 14 . . . born 1896.

YALE E. SMITH . . . (A'46) . . . chief instructor, Aviation Training Division, Territory of Hawaii . . . died July 30 . . . born 1897.

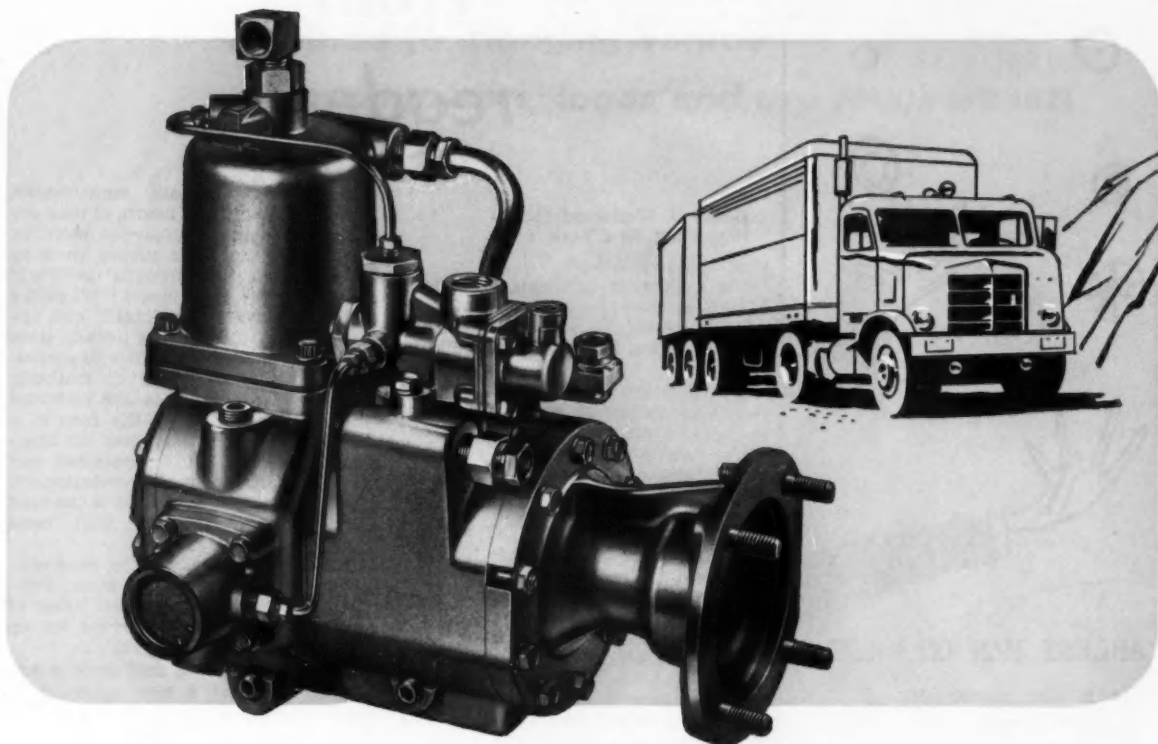
WILLIAM C. STEWART . . . (M'40) . . . technical adviser, Industrial Fasteners Institute . . . died February 6 . . . born 1902.

O. M. THORNTON . . . (A'26) . . . district manager, Titeflex, Inc. . . . died January 21 . . . born 1886.

RHYS O. WILLIAMS . . . (M'49) . . . technical staff, Hughes Aircraft Co. . . . died October 17 . . . born 1921.

ARTHUR YOUNGS . . . (A'21) . . . mechanical consultant . . . died December 19 . . . born 1872.

More air reserve for safer braking of diesel powered trucks...



with WAGNER ROTARY DRIVE-THRU COMPRESSORS

The Wagner Drive-Thru Compressor features all the advantages of rotary compression . . . supplies more air reserve for braking diesel trucks . . . gives rapid air pressure recovery with smooth, quiet, cool operation.

The design of the compressor eliminates the use of thrust absorbing components and makes it possible to use rotary seals with a minimum of seal loading. Improved channeling permits better oil circulation to all moving parts—lengthens the

service life of the pump and cuts maintenance.

NEW LUBRICATING VALVE. The lube valve on these units circulates cool engine oil through the compressor during the non-pumping cycle and cools the compressor between cycles by completely changing the oil in the sump. Compressor life is prolonged by constant, adequate lubrication.

For full information on these compressors, write to Air Brake Engineering Department, Wagner Electric Corporation, St. Louis 14, Missouri.

WK59-9

Wagner Electric Corporation

6378 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

LOCKHEED BRAKE PARTS, FLUID, BRAKE LINING and LINED BRAKE SHOES • AIR HORNS • AIR BRAKES • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES



ABLEST MAN ON WHEELS

He's the experienced
ELECTRIC man. Call him
for the quickest answers
and quotes in the
industry today.

Your ELECTRIC sales engineer is an able helper when it comes to putting your ideas on wheels. He can help you with a new design, make cost-cutting suggestions for a redesign, give you prices while you're planning.

What's more, we back him up — with the production capacities and qualities of an automated operation, an ideal location and years of agricultural and industrial experience.

Call or write today for the exact disc or spoke-type wheel (steel or rubber tired), rim, hub, axle or component part you're looking for.

"What we sell is service"

ELECTRIC WHEEL CO.

Write to Department 11C
1120 N. 28th St., Quincy, Illinois, 8Aldwin 2-5320
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

letters from readers

From:
Henry H. Wakeland (M'48)
New York, New York

Dear Editor Shidle:

I've read your editorials for a long time and have been impressed with their thoughtfulness and gentle approach. Often I've seen much truth in them.

Now I notice that you've used two monthly columns in a row to criticize the critics and reformers, and that you're stressing positivism instead. Might I suggest that it would be a good idea to try positivism on the critics? Instead of attacking open argumentation, help it to be rational.

For example, you might run a "battle column" such as the New York papers do. Invite Col. Stapp to take one side of a page to tell about his technical views on crash safety. Offer Charlie Chayne the other side of the page to tell about his somewhat different views. Then ask some distinguished citizen to write an evaluation of the arguments. Roy Campanella, for instance.

The point is that criticism and argument must be heard if the process of

change is to remain constructive. When the minds and hearts of men are subject to policies supported more by strength or courteous silence than by other factors, the strength itself will necessarily become a target. When the destructive type of reformer has appeared in history, it has usually been because it seemed impossible to accomplish reform by "positive" methods. George Washington was one positivist who finally gave up in the face of a great power. He kicked over the stagnant bucket of British evolution and became a determined revolutionary. The Washington Monument is the kind of "Statue to a Critic" that 'most everyone knows.

Yet G. W. won because he used constructive methods. They were "positive" and correct for the new frame of reference which he helped to set up and for which he risked all.

Personally, I doubt that there is any way to say that a new approach is better than an old one without labelling the old one as bad. Possibly that is the logical fallacy in "positivism" or Pealeism, or whatever one calls it.

From:
Dr. A. D. T. Libby (M '14)
East Orange, N. J.

Dear Editor:

I was quite interested in the Electric Auto-Lite advertisement on pages 14 and 15 of the March 1959 SAE Journal. They should be interested in an article I presented before the SAE in 1914 (see pages 149-166 of the 1914 SAE Transactions, Part II). Many of my tests were made in the early days of the Vanderbilt Highway, that was being built about this time.

I quote one sentence from page 150 of that 1914 SAE Transactions: "Thus we see that the 6-volt system is the result of a great deal of patchwork; while a great many of the rough edges have been knocked off, yet it is the belief of the writer that it never has been an entirely satisfactory job, and possibly never will be; that is, it cannot be made as satisfactory as a 12-volt system."

Now the automobile industry is doing

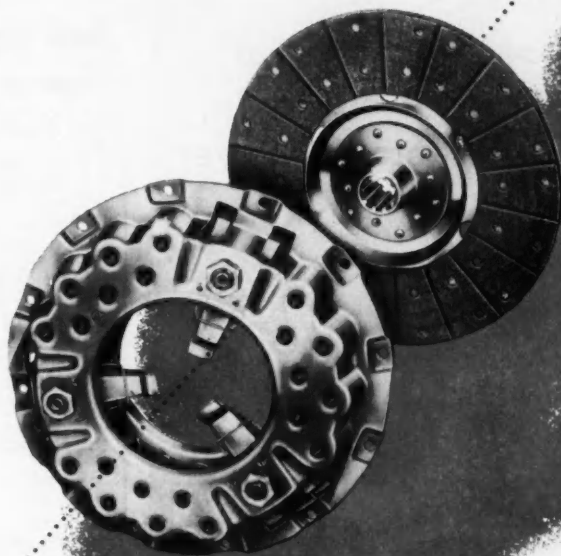
what I wanted them to do nearly 50 years ago, use 12-volts.

As you doubtless recall, I was president of the Automotive Electric Association for seven or eight years and during that period we had one summer meeting at Old Orchard, Maine. I arranged for an old-time clambake in a pine grove at Blue Point, Scarborough, and I had my brother from the old farm in Beech Ridge, Scarborough, bring down 15 gallons of old cider made on the farm.

By the time we got through a trip I arranged through Portland Mills at Cumberland Mills, etc., the "gang" was thirsty and how they did pour down that cider, so when the eating started, they didn't know a clam from a lobster. After dinner, we started a ball game. When I started to throw to the batter, I shifted and threw to first base to catch the runner, and the umpire, treasurer of Leece Nevil Co., shouted, "Strike one." I never will forget that. He didn't know where the ball went.

LIPE

***Adapted to changing vehicle
horsepowers, loads and use requirements***



***That's why you get more ton-miles and more
engagements per mile out of a Lipe Heavy-Duty Clutch***

At Lipe-Rollway our automotive division makes heavy-duty clutches...and nothing but heavy-duty clutches. We've been devoting our research, development, technology, equipment and skill to that job for years.

Today, the list of Lipe clutch users reads like a "Who's Who" of the heavy-duty vehicle industry. Tens of thousands of Lipe clutches are in daily service... thousands more are added each year. That is because our constant aim has been to build a more serviceable clutch, continuously adapted to changing vehicle horsepowers, loads and use requirements.

Advanced equipment, flexible deliveries, shorter lead times, a planned program of design development, all make Lipe the clutch best suited to serve you. *Let our engineers work with your men to give you a clutch engineered to your job. Write for information.*



MANUFACTURERS OF AUTOMOTIVE CLUTCHES AND MACHINE TOOLS

Continued from p. 104

special tools, or where skilled workmen are lacking. Studies of the practice may show that many operations can be done at less expense by being sent outside.

Consider battery rebuilding. Few fleets can justify a battery repair and rebuilding shop. Few fleets regrind crankshafts. But what about unit repair? Unless a great many electrical units are consumed and a specialist can be employed to rebuild such units as generators, starters, carburetors, and regulators, outside shops may be

set up to do it cheaper — if cost studies prove it out. This can be determined easily. But what about engine rebuilding?

Many smaller fleets are now sending engines to rebuilders and dispensing with tools, shop, and labor costs. In many cases this applies to vehicles domiciled in outlying districts, but it could well be true of a large operation, especially where costs are out of line with surrounding markets.

The same principles apply to leasing or renting of vehicles, or employment of dealer repair facilities for certain operations. Studies may show some of this responsibility can be trans-

ferred to another agency — at a price that can be afforded in view of the specific problems.

Have new ideas been tried recently? If some were considered and turned down a few years ago that does not necessarily provide answers for today. The picture is changing. Better use of ideas has become a most important function of the progressive fleet maintenance superintendent.

To Order Paper No. S142 . . .
on which this article is based, see p. 6.

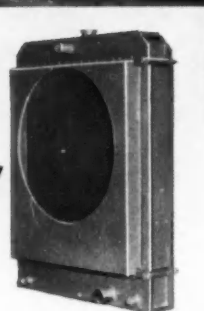
Young designs special radiator with built-in oil cooler for Huge New Tractor-Scraper



Clark Equipment Company's Michigan Model 310 Scraper.

MONO-WELD® Radiator by *Young*
Cools both water and oil
under toughest operating conditions

Cooling giants like this Michigan Model 310 scraper is a job calling for Young radiators. By designing a radiator with a special core section at the bottom equipped with patented turbulators for cooling the lube oil, Young eliminated the need for a separate oil cooler. Special construction features of the Mono-Weld Radiator insure maximum heat transfer and dependable ruggedness to match the superior construction of this equipment.



Rear view of radiator shows connections for oil cooling.

Young radiators are used where the going is tough



Write Dept. 119-E
for catalog No. 148A

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Moline, Illinois

Rolls-Royce Diesels Come in "57 Varieties"

Based on paper by

R. H. WHITESIDE

Rolls-Royce of Canada, Ltd.

(As reported by Gregory C. Meyer, SAE Philadelphia Section Field Editor)

IN designing light-weight high-speed diesel engines for sale in Great Britain and for export, we emphasize versatility in size and configuration and interchangeability of components. From a simple and orthodox engine design, based on a cylinder of 5½-in. bore and 6-in. stroke, engines were developed in the following basic arrangements:

- Four, six, and eight cylinders, with swept volumes of 495, 743, and 990 cu in., respectively.
- Turbocharged, supercharged, and normally aspirated.
- Wet or dry sump lubrication.
- Left- or right-hand build.
- Horizontal or vertical configuration.
- Single or coupled units.
- A variety of take-off points, with full engine power from the front of the crankshaft.

Rolls-Royce diesel engines have a combustion system resulting in high thermal efficiency and low specific fuel consumption. Some of the special features of these engines include an extremely rigid crankcase design, fully machined and nitrided crankshaft, aluminum-alloy pistons with a machined toroidal cavity combustion chamber, easily replaceable wet cylinder liners, specially heat-treated in zones of greatest stress and wear. Particular emphasis has been laid upon sealing of combustion chambers and water passages, filtration of both lubricating and fuel oil, and controlled cooling water circulation around the cylinder liners, valve seats, and injectors. Various types of timing cases for numerous assembly variations are applicable for all engines in the range.

These engines have exceptionally

Continued on p. 117

Handy & Harman EASY-FLO 35 So Effective Yale & Towne Redesigns 39 Parts for Silver Brazing

See This Being Made at the Design Show

*...BRAZED
Fork Lift
Clutch Cage
jolt and
accident
proof*



Clutch cage for Yale & Towne's Industrial Trucks; fabricated by John V. Potero Company, Inc., Philadelphia.

One of the problems in operating a fast-moving, stop, go and back-up fork lift truck is accidental overtravel of gear-shifting from forward to reverse and vice versa. The result, of course, is a useless unit.

This simple clutch cage makes it impossible to jam a fork lift's gear box with resulting time lost for repair. The operator can't make a mistake.

The frame and shaft, of separate pieces, are made of mild steel. The shift lever lock, in the center of the shaft, is made of hardened steel. It is positioned by two tubular sleeves of mild steel. The entire assembly is hand torch-brazed with EASY-FLO 35 and HANDY FLUX with no loss of hardness.

Welding was considered but rejected because of

the necessary follow-up of "spatter" cleaning. With simple silver brazing, flux removal is the only finishing operation required. This, plus the fact that silver brazing is much *easier* (your operator need not be a practiced "torchbearer"), has prompted Yale & Towne to redesign thirty-nine of their parts and components so that they can be brazed.

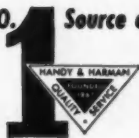
Come see this part being brazed at the Design Engineering Show in Philadelphia, May 25 through 28; at Handy & Harman's Booth 115. Any questions you may have between now and then about silver alloy brazing and the benefits it imparts to thousands of components, parts and assemblies, may be addressed to Handy & Harman, 82 Fulton Street, New York City 38.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



Your NO. 1 Source of Supply and Authority on Brazing Alloys

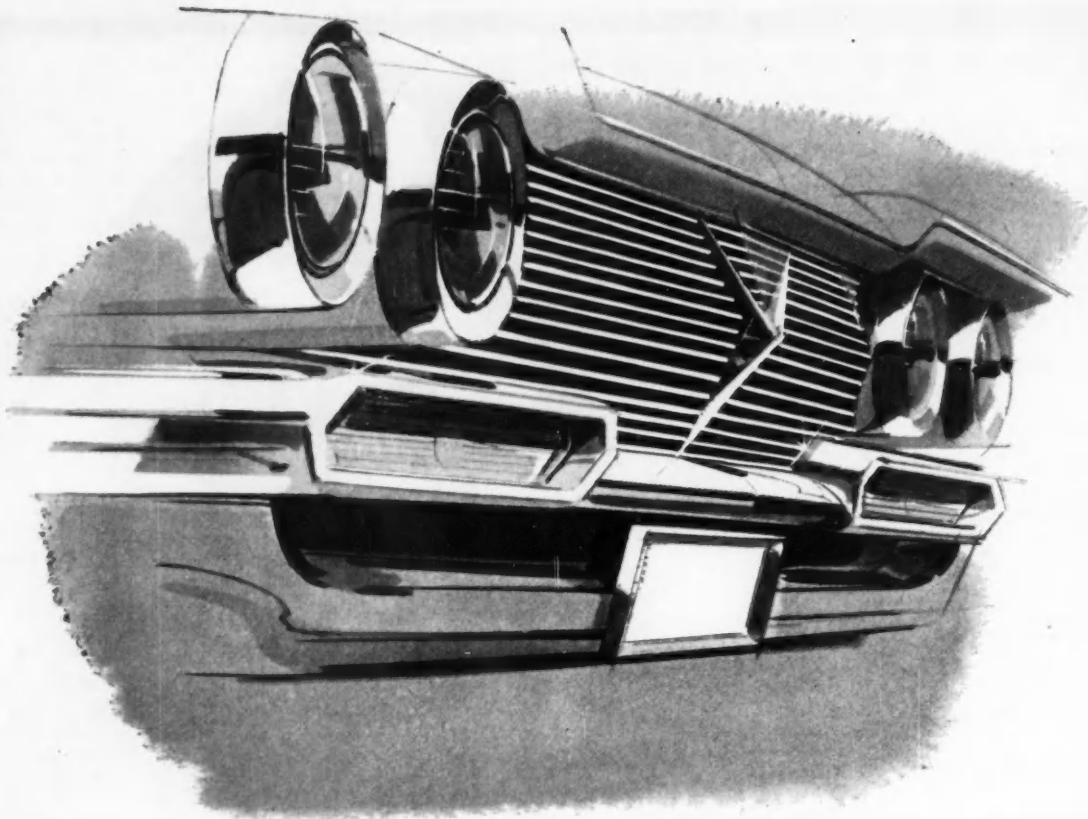


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good cold-starting properties. Environmental testing is a feature of the development test program and development test cells are connected to a central electronics laboratory, which is also equipped with tape recording units for preserving test results. A full-scale test rig simulating railcar service with repeated cyclic operation reproduces any required operating route.

To Order Paper No. S176 . . .
on which this article is based, see p. 6.

Let's Clear the Air On Modern Motor Oils

Based on talk by

J. D. BARTLESON

Ethyl Corp.

(As reported by Dale E. Woomert, SAE Baltimore Section Field Editor)

WHAT is ahead in motor oils? Perhaps it is best to look at what has gone before and why. In 1932, with the advent of alloy bearings, a bearing corrosion inhibitor became necessary. About this same period the solvent extraction process took the place of the old sulfuric acid method. This resulted in an increased output and improved V.I. characteristics. In 1940, to meet engine cleanliness requirements, about a 1% detergency level was established. By 1945 high-sulfur fuels required this to go up to 4-8%.

In 1947 automatic transmissions imposed the requirement of a 135 V.I., and a 2-4% additive level was established to meet this need. In 1950 hydraulic valve lifters became the critical area, with more detergency needed and an alkalinity requirement.

The year 1952 saw compression ratios on the way up, with octane and surface ignition the problems. The result was more volatile base oil with 7% V.I. improver. In 1953 higher power brought on cam and tappet wear and the addition of 3% phosphorous.

What is the typical oil today? Well, it depends on the base stock, but it would be something like that presented in the table below:

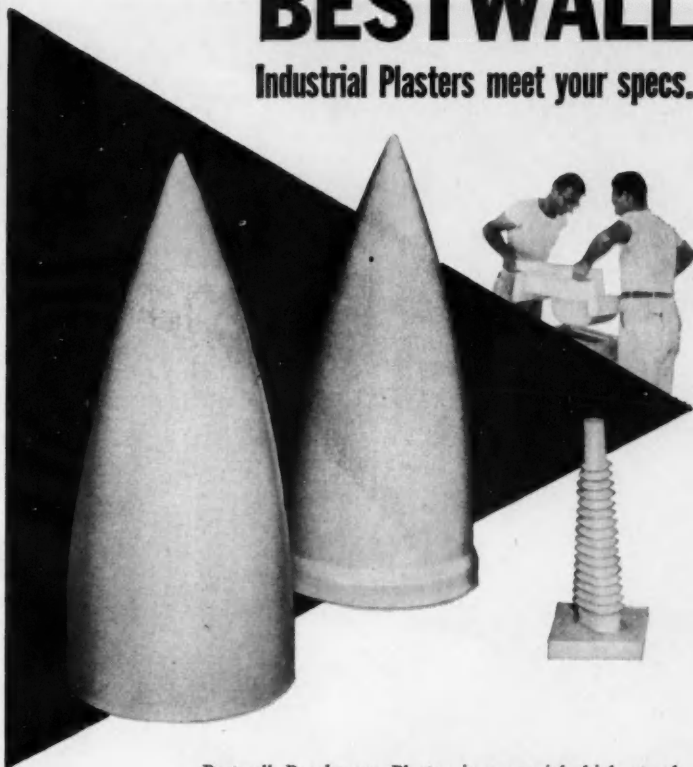
	Concentration, %	Cost, \$/gal
V.I. Improver	7	15
Antioxidant	3.5	8.5
Dispersant	6	15
Total Chemicals	16.5	38.5
Oil	83.5	20.0
Total	100.0	58.5

Now, what is left for the future? Anti-ORI additives have not been completely exploited. Better cold sludge dispersants are a must. Antiwear qualities will have to be improved.

for working molds or exacting models

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All Bestwall Industrial Plasters may be tailored to your specifications, e.g., very slow to extremely fast setting time, controlled expansion, alkalinity.

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Here's why your fleet customers specify Purolator Air Filters as original equipment



"We've saved thousands of dollars in maintenance costs by preventing dirt damage to our engines," says Mel McLure, Shop Supt., Yellow Transit Freight Lines, Inc. He specifies Purolator dry-type air filters exclusively for Yellow Transit's fleet of 302 Kenworth line haul tractors.

This quote points out one way to increase chances of repeat business. Your engines will last longer in the field, and his maintenance costs and down-time will be cut sharply, when you've built Purolator dry-type Micronic® air filters into his diesels.

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- They are more than 99% effective at all engine speeds.
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Think about these benefits when you consider Purolator air filters for original equipment in your own, standard line of diesels.

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Continued from page 6

relation of vehicle temperatures; studies of octane number requirement and fuel knock-rating; studies of rumble and knocking surface ignition and of cold starting and warm-up performance; carburetor icing and vapor lock.

New Concept of Light Weight Highway Tractor Design, C. V. CROCKETT, D. J. LABELLE. Paper No. 23R. Design of tractor produced by General Motors Co., capable of pulling single trailer at GCW of 61,000 lb; vehicle is powered by 6-71 GM 2-cylce diesel engine which could yield over 200 hp; when operating in lower gears, governed engine speed is 1800 rpm; in two highest ratios, max engine rpm is 1650; performance curves; frame construction; tests to determine stress and strain pattern; suspension and steering linkage; other particulars.

Firebird III — General Arrangement and Body Design, R. F. McLEAN, S. HABSBURG. Paper No. 24R. Overall design of experimental automobile; integration of appearance and aerodynamic requirements with structural and performance characteristics; how, by means of single handle, Uni-control, placed between two passengers so that either can drive, it is possible to control power, direction, and deceleration; arrangement of major components which include engine, transmission, accessory engine, fuel, tires, controls, electronic and hydraulic equipment.

Chassis and Control Details of Firebird III, J. B. BIDWELL, R. S. CATALDO, R. M. Van HOUSE. Paper No. 24S. Chassis configuration, details of mechanical design, accessories and electronic control systems of experimental car, built by General Motors Co. to evaluate advance design characteristics; data and specifications; electronic driver-Unicontrol vehicle system; steering system design parameters, components and servo performance; separate auxiliary engine driving air conditioning compressor, oil pumps, and generators at constant speed.

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Reader Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.

GT-305 Regenerative Engine in Firebird III, W. A. TURUNEN, J. S. COLLMAN. Paper No. 24T. Features of GT-305 Whirlfire gas turbine consisting of turbines arranged on common horizontal axis; designed for inlet temperature of 1650 F, first stage turbine turns radial flow compressor at 33,000 rpm through connecting shaft; second stage power turbine drives output shaft through single stage helical reduction gear and develops full power at 24,000 rpm; details of two drum shaped regenerators, gasifier and power turbine assembly and components.

Effects of Higher Engine Speed and Power on Clutch, J. R. LUDWIG. Paper No. 25R. Two basic solutions to clutch problems encountered with higher engine speed in heavy duty applications are to improve materials for use in single plate clutches, or to use multiple plate clutches; comparative design and laboratory test data of 11-in. 2-plate clutch and 14-in. single plate shows that use of 2-plate clutch permits weight saving of 24¼ lb; results of tests obtained with 2-plate clutch, installed on tractor with trailer.

Effects of Higher Engine Speeds and Power on Truck Transmissions, W. LEONARD. Paper No. 25S. Factors to consider and means of handling higher engine speed characteristics by transmission design; internal functional effect on gear shifting and mechanical means of preventing gear clash by employing synchronizers; external functional factors affecting transmission operation and life; effects of increased power; it is found that present countershaft transmission if properly designed is satisfactory for delivering to driving wheels available speeds and power.

Effects of Increased Engine Speeds and Power on Driving Axles, N. R. BROWNYER. Paper No. 25T. Discussion confined to single speed axles of bevel gear type, both spiral bevel and hypoid, in motor truck applications; laboratory tests indicate that gears scuff more at high speed than at low speeds; recent tests produced improvement in scuff load capacity on small gear set by changing ratios from 7-1/5 to 7-1/6 or change in tooth combination from 5 into 36 to 6 into 43; suggested partial solutions for actual designs if engine speeds increase further.

Large Scale Highway Research — AASHO Road Test, W. B. McKENDRICK, Jr., W. J. SCHMIDT. Paper No. 26R. Test facility at Ottawa, Ill, sponsored by Am Assn Sate Highway Officials, consists of six loops of pavement; construction details; fleet of test vehicles ranged from trucks to tractors and semitrailers; recording equipment and instruments used to measure surface deformation; objectives of tests, most important of which is to deter-

Continued on page 121

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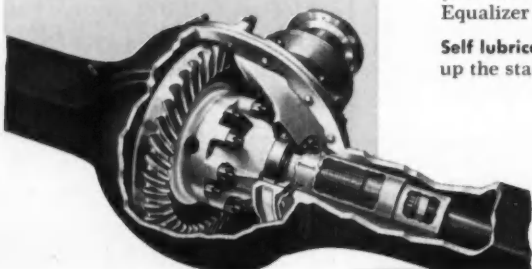
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Safer, surer operation. A truck equipped with the Rockwell Traction Equalizer is easier to control on curves, slippery pavement and soft ground. The tendency of a vehicle to swerve when one wheel suddenly loses traction is eliminated because wheel spinning is reduced.

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Continued from page 119

mine significant relationships between performance and traffic for pavements of certain designs under controlled traffic with certain loadings.

Multiple Shoe Brakes for Higher Torque, P. A. SMITH, P. F. BLACK. Paper No. 268. Design features of Hi-Torque Brake, developed by B. F. Goodrich Co, to meet brake requirements in earthmoving machinery; brake actuation is flexible hydraulic platform and actuation system is able to deliver up to 22 cu in. of hydraulic fluid up to max of 700 psi; master cylinder consists of cylinder, actuation piston, and automatic adjusting piston assembly; operational procedure; results of tests carried out with International Harvester truck and 4-wheel tractor pulling scraper.

MATERIALS

Performance and Economy Gains with Light Weight Materials, G. W. NIEPOTH. Paper No. S145. Work at General Motors shows that aluminum automobile castings cost less to produce though raw material is more expensive and that reduction in vehicle weight increases operating efficiency; available methods (sand casting, semi-permanent and permanent mold, and die casting) examined to show adaptability to aluminum cylinder block casting; substantial gains in fuel economy and performance result without sacrificing ride, load capacity or comfort.

MISCELLANEOUS

Subjective Measurements in Engineering, J. VERSACE. Paper No. 218. Extent to which measurement involves human judgment and why correspondence between sets of measurements cannot be greater than reliability of making them; therefore, rating program must be rigidly controlled according to procedures of experimental design; procedure used at Chrysler Corp illustrating how correlation is found between physical measurements and rating; example given refers to evaluation of seven different cushions for relative static comfort. 31 refs.

PRODUCTION

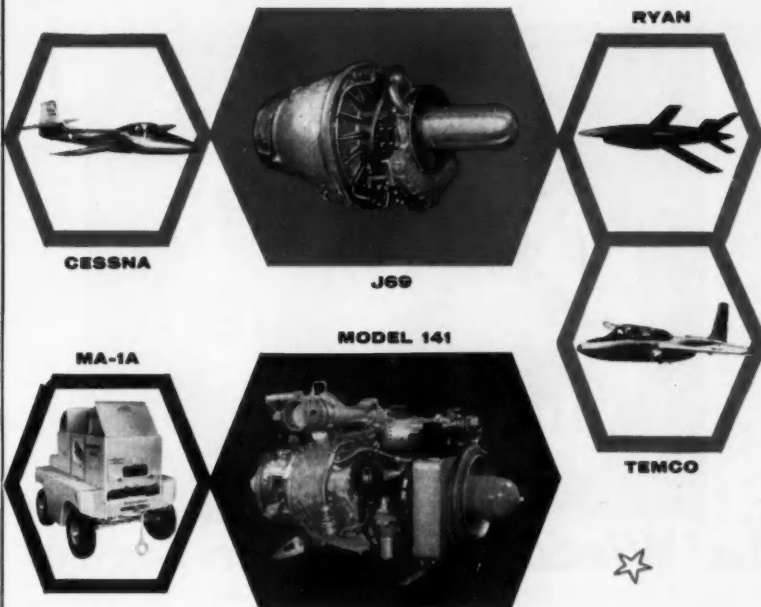
Pontiac Motor Division's Material Utilization Program, C. O. JOHNSON. Paper No. 27E. Pontiac's Material Utilization Program involves reduction, substitution, elimination or conservation of tools and materials; function.

Continued on page 122

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Continued from page 121

tions and tasks of committee-type organization which covers every ac-

tivity and area; sample reports written by committee members included to describe varied approaches used in different types of activities; five examples of savings achieved.

Remain Competitive — Analyze Cost of Production Per Square Feet of Floor Space, A. F. SCHROEDER. Paper No. 278. Analysis intended for smaller plant requiring careful planning and cost reduction program; suggestions made with respect to use of conveyors, either roller or chain; mechanical load-

ing and unloading devices and means of transferring work from one machine to another, thereby reducing material handling cost; tools, jigs, and fixtures; illustrations refer to truck axle manufacture.

General Electric's Approach to Value Analysis, N. E. KEWLEY. Paper No. 27T. Problems associated with introducing value analysis into particular operation and products; recommendations made for carrying out value analysis program in given plant; value analysis as means of reducing product costs without reducing product's proper functioning or salable quality.



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You start with a rugged, heavy-duty WISCONSIN AIR-COOLED engine. Compact and light-weight to reduce bulk and fit your equipment. High torque for load-lugging power. Air-cooling for all-weather serviceability in any climate, any weather, anywhere. Here are the "extras" available from Wisconsin to complete the "power package" to most ideally suit your requirements:

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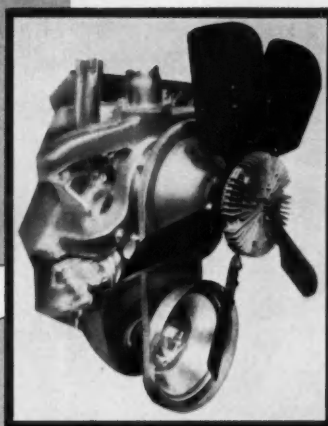
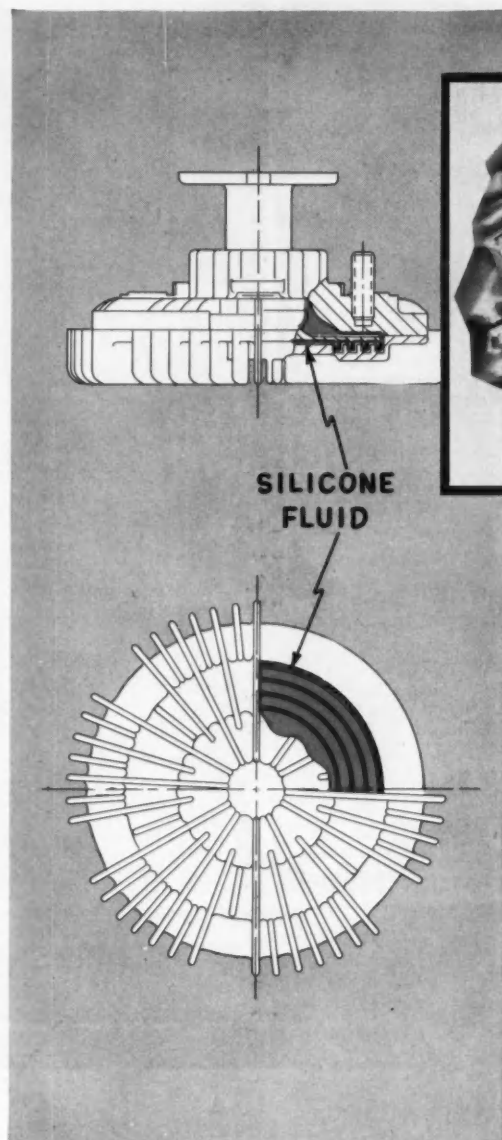
Advantages of New SAE Standard for Involute Splines from Design Standpoint, L. N. DeVOS. Paper No. 28R. SAE Standard which provides basis for selection of design that will satisfy assembly needs and yet be flexible enough to allow adjustments for specific performance and/or production conditions; reasoning and concepts applied; it is shown that it is possible to select standard splines that usually fit needs of end product; in rare cases where standard spline is not applicable, information included makes it possible to follow standard practice for specifications.

New SAE Spline and Serration Standard, G. H. SANBORN. Paper No. 28S. Advantages of new standard are discussed from tooling and manufacturing standpoint; description of methods used for cutting or forming of external and internal involute splines and serrations, as confined to working of cold metal parts; finishing operations; advantages of involute cutting tool compared with those for straight sided splines.

Advantages of Involute Splines and Serrations from Gaging Standpoint, A. S. BEAM. Paper No. 28T. Paper reviews relative merits of involute vs straight sided splines and serrations from inspectors' and gage makers' viewpoints; analytical inspection for spacing, profile, parallelism, space width and tooth thickness; functional inspection probes for fit with mating member in form of composite spline gage which checks whole active spline contour.

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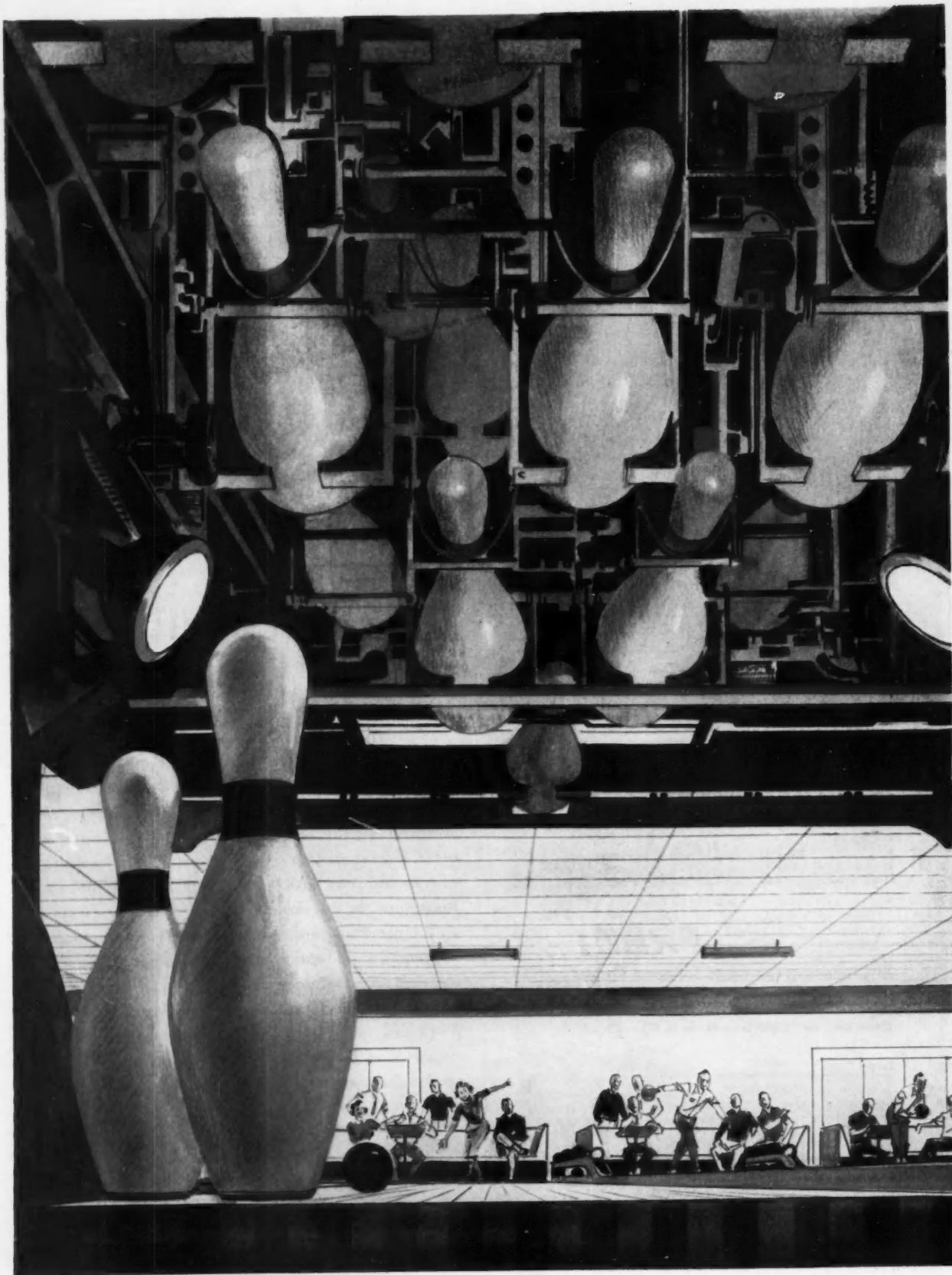
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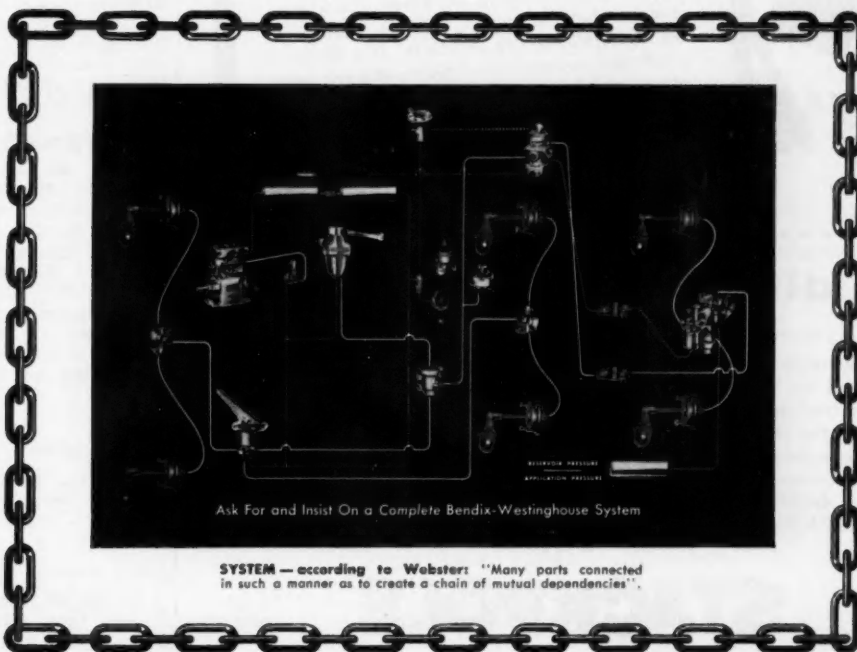


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These applicants qualified for admission to the Society between March 10, 1959 and April 10, 1959. Grades of membership are: (M) Member; (A) Associates; (J) Junior.

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William Bruce McLean (J).

Baltimore Section

Frank E. Curran, Jr. (A), Walter John Eser, Jr. (M), Jervis B. Spindler (A), David A. Surrette (J).

British Columbia Section

David George Rennie (M), Claude Robert Usher (M).

Buffalo Section

Gabriel V. Pesce (M), Galer N. Wright (M).

Central Illinois Section

Joseph K. Adelman (J), Gary Oren Bragg (J), Donald R. Crews (J), Richard Albert Day (J), Willis Dale Dillon (M), Ernest Duane Duvall (J), Earl W. Hagen (J), Carroll G. Hakenson (J), Don D. Hamilton (M), James L. Hopper (M), Walter Stacy Hulvey (J), Arthur R. Jensen (M), Robert Arnold Jones (M), Gerald F. McDonough (J), Payson B. Palmer, Jr. (J), Robert L. Rodgerson (A), Robert Dean Sappington (J), Herman P. Siebels (M).

Chicago Section

David M. Cowan (M), Frank A. Doody (M), Ralph James Erisman (M), Robert William Gallagher (J), Frederick H. Harrison (A), C. Elmer Johnson (A), Myron A. Jones (M), Hubert Raymond Kerwin (A), William J. Kremer (A), Richard Daniel Miech (M), William L. Ronney (M), George P. Scelzo (M), Darrel R. Schultdt (J), William A. Shields (J), Robert J. Ullstrup (M), James Clifford White, Jr. (J).

Cleveland Section

John O. Antonson (M), Phillip D. Huculak (A), Russell R. Lussier (J), Wallace L. Pepin (A).

Detroit Section

Ronald W. Ballantyne (J), James E. Collins (M), Raymond L. Fales (J), Walla Leon Ferris (M), Kenneth S. Grilleaux (M), Denzil L. Hammond (M), John L. Harned (M), Nicholas Hintyes, Jr. (M), R. E. Hoffmann (M), John T. Huntington (A), Fred S. Kerr (J), Robert L. Kingsbury (J), Theodore J. Kona (M), John T. Kowall (M), George Mardiros, Jr. (J), John W.

Continued on page 128

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San Francisco, Seattle
Toronto, Tulsa

New Members Qualified

Continued

McCauley (M), Carl C. Mueller (A), Chester K. Murphy (M), Merle R. Osborn (J), Densmore K. Rheume (A), James L. Roush (A), Donald William Seal (M), Tanas M. Sihon (J), John M. Slessor (M), Donald S. Snider (M), Raymond J. Tolinski (J), Remi A. Van Steenkiste (M), John D. Van Veen, Jr. (M), Ernest H. Wagner (A), James W. Watson (A), Philip West (M), Kenneth James Williams (J).

Hawaii Section

Alexander G. Budge, Jr. (A), Larry Grant (A).

Indiana Section

Ervile J. Bitler (M), Harry L. Boese (M), Alan Bott (M), Anthony Francis Brodnicki (J), H. J. Claypool (M), Bruce W. Davis (M), Kenneth B. Harmon (J), John G. Mehagan (M), Orban H. Reich (M), Bernard H. Rullman (M), John J. Schoeberle (J).

Kansas City Section

John H. Woodsmall (M).

Metropolitan Section

Edmundo Badler (J), Edward Boughton (M), Joseph M. Burrows (A), David Fellows (M), William T. Graham (M), Clark J. Grey (A), Stanley M. Jackson, Jr. (J), William Lawrence Kennedy (M), Walter Robert Looker (A), Marco Lucatorto (A), Martin T. Mobach (M), David A. Reisman (J), Andrew V. Santulli (M), Stephen J. Smigielski (A), Carl A. Swenson (M).

Mid-Michigan Section

Howard Daniel Brown (J), Maurice J. Christianson (M), Alfred C. Drouillard (M), Howard H. Gehring (M), Carl Albert Koerner (M), Donald H. Markwood (A), Robert C. Oakes (J), Robert B. Robinson (J).

Milwaukee Section

Keith F. Kummer (M), Ronald A. Peterson (J), Joseph P. Plevak (M), Robert Gates Rawson (M), James S. Scott, Jr. (M), Joseph M. Ziabicki (M).

Montreal Section

Alex F. Morrison (M).

New England Section

Richard Dawson Cavanaugh (M), James Arnold Kiely (A), Robert H. Thesing (A).

Continued on page 131



When CONTROL cannot be a question of degree . . .

Exacting engine control believed impossible only a few years ago is now the expected, not only in modern aircraft and missiles, but also in today's automobiles and trucks. And, this absolute accuracy is demanded under temperature, pressure, and power conditions found, until recently, only in laboratories. Temperature variations alone of -80°F to $+160^{\circ}\text{F}$ require almost continuous compensations in today's jet aircraft and

missiles. More, these ever-increasing requirements must be designed for ever-decreasing standards of size and weight.

For more than a half-century, Holley has pioneered such developments as: lower automotive hood lines through smaller carburetors and fuel control systems for jet engines that save one-third the weight, one-fourth the space. That's why two generations of Americans on the move have come to depend on Holley products.

*For more information about
Holley products, automotive or
aircraft, write to*

HOLLEY
Carburetor Co.

11955 E. NINE MILE RD.
WARREN, MICH.

1-30

FOR MORE THAN HALF-A-CENTURY . . .
ORIGINAL EQUIPMENT MANUFACTURERS FOR
THE AUTOMOTIVE AND AIRCRAFT INDUSTRIES

Economy, Efficiency



Lycoming
IG50-480 Engine

Beech
G50 Twin-Bonanza

Photos Courtesy: Lycoming Div. Avco. Mfg. Co. and Beech Aircraft Corp.

and
Elimination of
Carburetor Icing...

FUEL INJECTION BY

SAE **SIMMONDS**
AEROCESSORIES, INC.

GENERAL OFFICES: TARRYTOWN, NEW YORK • BRANCH OFFICES: GLENDALE, CALIFORNIA • SAN DIEGO, CALIFORNIA • WASHINGTON, D.C. • DAYTON, OHIO • ST. LOUIS, MISSOURI • DALLAS, TEXAS • DETROIT, MICHIGAN • SOLE CANADIAN LICENSEE: SIMMONDS AEROCESSORIES OF CANADA LIMITED, HAMILTON, ONTARIO



New Members Qualified

Continued

Northern California Section

Charles W. Besso (M), Jack F. Hecht, Sr. (M), Clinton A. Phalen (M), Kenneth E. Unmack (M), William Albert Wallace (A), James Frazer Wellington (J).

Northwest Section

Frederic Kemble Brunton (M), L. J. "Bud" Gilroy (A), John William Postma (J).

Ontario Section

C. H. Bottoms (M), Gordon McKay Break (M), Andrew G. Douglas (M), Colin Lister James (A), Edward J. Koenka (M), Robert D. MacLean (M), Allan Ross Scott (M), William Hugh Scott (A), Terrence Barry Seawright (J), George G. Wellington (M).

Oregon Section

Robert L. Barnes (A).

Philadelphia Section

John A. Keller (J), William M. Marcussen (M), Oreste Christopher Quattro (J), Samuel R. Robb (A), Ralph G. Rutman (A), Lester J. Stradling, Jr. (M).

Pittsburgh Section

Elbert S. Howarth (M), Richard G. Roesing (A).

St. Louis Section

Walter T. Posey (M), R. O. Tuegel (M).

San Diego Section

Wilton R. Dortch (A), Roy Bernard LeMaster (J), Billy Dean Mahin (J), A. H. Riley, Jr. (M), Donald D. Shirk (M).

Southern California Section

George C. Chalmers (M), Boland Golestan (A), Harris J. Howard (M), Paul A. Jacobs (M), Wm. J. Kennedy (A), Daniel Lehrer (M), William A. MacFarland (M), Fanning T. Oakley (J), Gerald D. Potter (A), James Rex Pruett (M), James Thomas Reilly (M), Robert Wilson Rouse (M), Paul A. Supancich (J), James G. Weldon (A), E. H. Whitney (M), John F. Yocom (M), Henry Richards Zahner (A), Eugene B. Zwick (M).

Southern New England Section

Richard E. Evans (M), Jay S. Tupper (J).

Texas Gulf Coast Section

James E. Nelson (J), L. T. Thompson (A).

Texas Section

Roger Edward Davidson (A).

Twin City Section

Loy David Jones (M), Albin E. Larson (M).

Washington Section

Bernard S. Beavan (A), Donald Allen Kaul (J), James D. Reeves, Jr. (J).

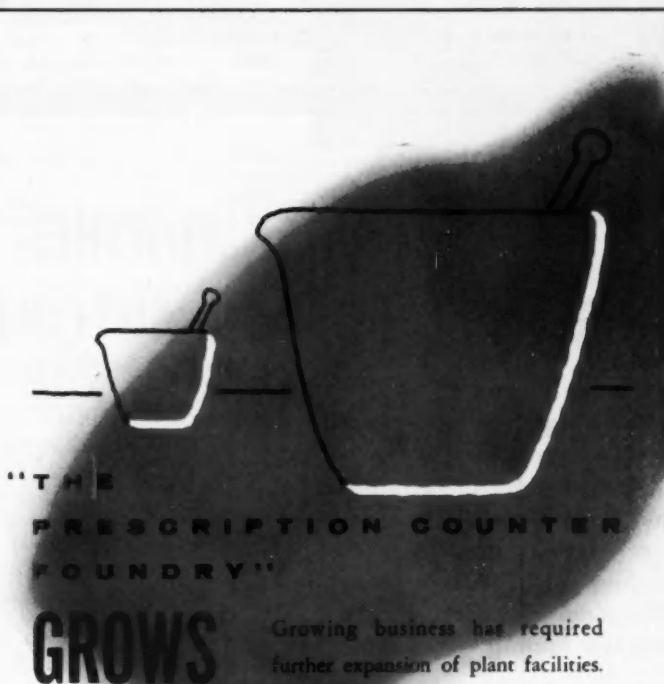
Western Michigan Section

David L. Mayrose (J).

Wichita Section

William Charles Benson (M).

Continued on page 135



Growing business has required further expansion of plant facilities.

Part of this business increase comes from new kinds and sizes of ferrous alloy castings, made for new customers in diverse industries. The remainder of the increase comes almost wholly from existing ECI customers. In both instances, the extreme care with which ECI adheres to the formulae, meets the specifications, and controls the product quality has been responsible.

Suppliers of critical component castings to the automotive, aircraft, hydraulic, and special machine industries since 1946



ENGINEERING CASTINGS, INC.
Marshall, Michigan



News of "material" interest

New and improved thermoplastics are giving automotive designers and engineers a new dimension in which to work. Old barriers to progress, set by less versatile materials, are being broken by these modern materials with the most to offer in the way of product improvement and production economies. Here are examples of such developments which are materially aiding automotive men . . . right now.

You may wish to check certain items in this advertisement and forward to those concerned in your own company.

ROUTE TO:

LATEX FINISHES REDUCE FIRE HAZARDS ON AUTOMOTIVE PAINT LINES

The magic of latex masters metal in new Dow Latex 566 for baked automotive primers. These new water-thinned coatings reduce fire hazards in paint departments. They can materially reduce insurance risks — improve coating performance.

There may soon be something missing around many spray booths and dip tanks in modern automotive paint departments. It's the expensive fire prevention equipment that now guards this hazardous area of automotive production.

The omission will be intentional, however. Revolutionary Dow Latex 566 can make the man in the spray

booth as safe from fire as a man sprinkling his lawn.

For much the same reason that it's cheaper to insure a water tank than a gasoline storage tank, insurance rates can drop when this new and modern material replaces conventional solvent-thinned paints. The thinner for finishes based on Dow Latex 566 can be drawn from any convenient water tap.

But Dow Latex 566 does more than lessen fire hazards. With it, industrial paint firms formulate superior finishes for metal.

The most startling new benefits in the use of Dow Latex 566 are linked to the fact that it is not a solution but a dispersion of discrete resin particles. Because molecular weight is not limited by viscosity, coatings requiring the additional properties derived from higher molecular weight than obtainable from conventional solvent systems may be formulated at spraying viscosities.

In addition to primers and finishes for parts, Dow Latex 566 promises excellent possibilities for other automotive applications. Complete information on the background and future of these revolutionary finishes can be obtained from Dow.

But first, check this next Dow thermoplastic material that builds gridiron durability into shop equipment . . .



ETHOCEL:



Football helmet toughness for headlight aimer housing

Shop equipment like this headlight aimer housing has to withstand treatment as rugged as you're apt to find anywhere . . . even on the pro football gridiron.

That's why it's made of Ethocel®, the same tough, versatile material that goes into modern football headgear. Ethocel provides the greatest toughness and highest impact strength available over the widest temperature range of any thermoplastic. It withstands extreme shocks, resists chemicals. The dimensional stability of Ethocel means parts fit perfectly. And the glossy, attractive surface is easy to keep that way.

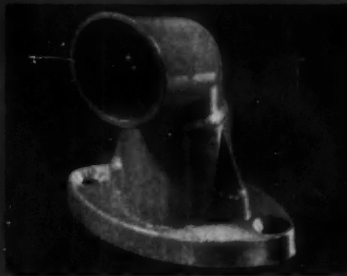
Investigate this rugged ethylcellulose molding compound for applications which demand its toughness, high impact strength and shock resistance.

If you aren't already profiting from these and other Dow thermoplastics, discover how you can. We suggest you write for complete information to Plastics Sales Department 1676EN5, THE DOW CHEMICAL COMPANY, Midland, Michigan.

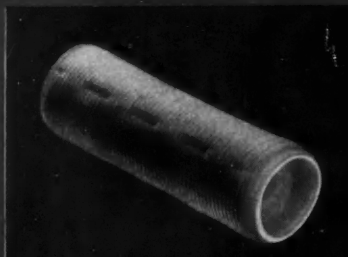
MORE NEWS . . . to help you profit materially



DOW POLYETHYLENE 990M. Excellent rigidity and elongation made it the specified material for this litter basket. Smooth, uniform flow permits low cost production by deep draw injection molding.



TYRIL. Special properties of heat resistance, toughness and color versatility made this comparatively new Dow thermoplastic the natural choice for this speed alerter assembly.



SARAN. No fouled gas lines, thanks to this SARAN filter which eliminates water and foreign material before gas leaves the tank. Hidden from sight, it has to be permanent, resist fuels and additives.



STYRON® 683. Passes the acid test for battery caps and name plates. Provides excellent acid resistance, adequate heat resistance. Colorful caps provide bright brand identification, too.

TYRIL:



Saves air conditioner maker a cool 19 production steps

One of the beauties of automotive air conditioning is right here . . . in this trim air conditioner housing made of Tyril® that resists dents, scratches, heat distortion, chemicals and oil.

Its maker finds real air conditioning comfort, however, in the fact that this tough, versatile styrene acrylonitrile copolymer cuts a total of *nineteen* steps out of the production line. That's right—19, including spot welding, cleaning, buffing and painting.

And, unlike metal, this housing can't rust or corrode in use. Tough, resistant, versatile. Tyril assures long life and precision fit for many molded parts.

DOW PLASTICS BASIC TO THE AUTOMOTIVE INDUSTRY

Molding Materials
Coatings
Extrusion Materials
Sheeting
Fabric Resins

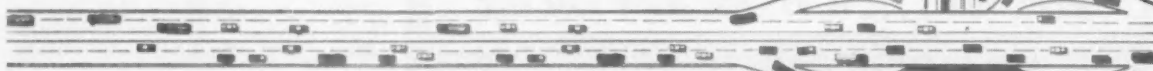
THE DOW CHEMICAL COMPANY
Midland, Michigan



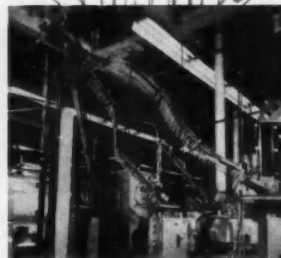
More than fifty years and a billion valves later

TRW's AUTOMOTIVE GROUP has a growing stake in America's transportation future

America on wheels means an America driving cars and trucks equipped with precision-manufactured parts produced by the five divisions comprising the Automotive Group of Thompson Ramo Wooldridge Inc. TRW's diversified and expanding future in cars and trucks is based on its fifty-year leadership in the industry, and on the many millions it has invested in new plants, new equipment and new methods of automated mass production. The Automotive Group sells \$100 million worth of automotive parts every year. Here are some typical examples: the more than a billion valves produced by the *Valve Division* are to be found in the majority of cars on the road today; the greased-for-life steering linkages produced by the *Michigan Division*... piston rings by *Ramsey*... high quality castings by the *Light Metals Division*... and world-wide distribution by the *Replacement Division*... all attest to the Automotive Group's deep product penetration. Moreover, TRW's scientists and engineers are engaged in broad supporting R & D programs for new developments for the years ahead. Whatever kind of car the future calls for—big car, small car, gas turbine—TRW is equipped in plant, knowledge, and experience to play an important role in producing it.

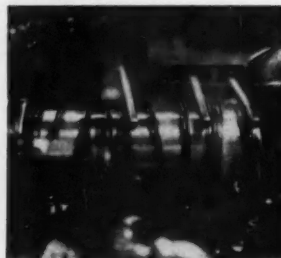


View of Valve Division's 100,000 square foot automotive valve packing and shipping department



Automatic valve finishing line

Piston ring production on the Norton automatic line



Thompson Ramo Wooldridge Inc.

MAIN OFFICES
CLEVELAND 17, OHIO
LOS ANGELES 45, CALIFORNIA

New Members Qualified

Continued

Williamsport Section

C. Warren Kline (M).

Outside Section Territory

Robert D. Charles (M), Floyd A. Derby (J), Harold J. Hennig (A), Ramsay R. Jackson (M), C. A. Lorenzen (M), Charles A. McKinnon (M), Carl F. Mickey (M), Leslie Earl Roby (M).

Foreign

Major G. C. Brady (M), Pakistan; Miss Marie Claire Cibie-Merenda (J), France; F. de Vries (M), Netherlands; K. Durairaj (J), So. India; Omkar Nath Fodar (J), India; Ferdinand Grumme (M), Sweden; Major Frederick William Harding (M), Australia; Patrick Laurence Ward Kelly (A), Australia; William Kennedy (M), Venezuela; Donald Henry Peebles (A), Australia; V. V. V. Surya Prakasa Rao (J), India; Kul Bhushan Rai (J), India; Rasam Chetty V. Rao (J), India; Dr. Mahmoud Hassaan Saadawi (M), Egypt; Thomas William Tillson (M), England.

Applications Received

The applications for membership received between March 10, 1959 and April 10, 1959 are listed below.

Alberta Group

John N. Piedmont

Atlanta Section

Charles M. Thomas

Baltimore Section

Richard B. Knox

Buffalo Section

Ralph F. Barth, John J. Hanrahan, James Russell Laskie, William Richard Niehaus, Fredric C. Ryan, Wallace H. Wagner

Central Illinois Section

John H. Altorfer, Alfred L. Baccheschi, Raymond E. Binkele, Willard Lee Birge, Joseph E. Bury, William S. Gripman, Robert Dale Janosov, George Johan Maat, Alvin W. Montgomery, Gene L. Stear, Donald J. Waugh, Noel Delbert Wiggins

Chicago Section

William T. Condon, Irving W. Doucet, I. C. Friedman, Louis W. Holtman, Donald D. Johannesen, Richard G. Klein, Louis Magazanik, Richard H. Nulf, James F. Prindiville, Lawrence Dale LaCroix

Cincinnati Section

Roger Walmsley

Cleveland Section

Andrew Ronald Baumer, Jack A. Davisson, William E. Foster, T. M. Kersker, Bernard A. Kuhl, Fred T.

Perkes, Lewis J. Valentine, John A. Retar

Dayton Section

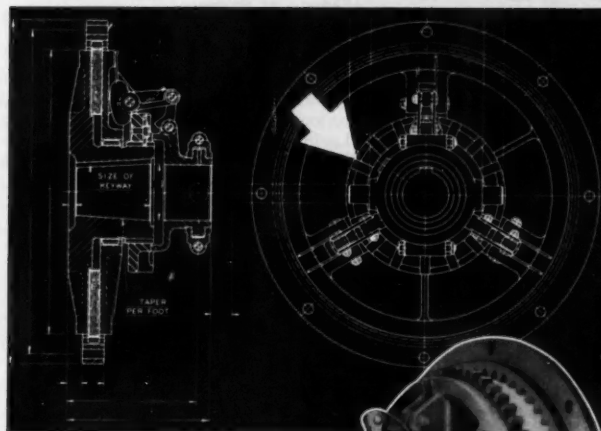
William F. Erickson, Robert J. Riner, Robert G. Kitson

Detroit Section

Roy F. Abell, Jr., Robert Alexander, Cecil S. Allen, Richard E. Allen, Roy L. Bailey, John M. Beamish, Robert W. Brandt, William G. Billmeier, Col. W. A. Call, Ben M. Callaway, Thomas H. Cape, Richard G. Clearman, Roy Adolf Gelpke, Ray E. Goeboro, Harold R.

Continued on page 136

ROCKFORD



OVER-CENTER Gear Tooth Drive CLUTCHES

Provide for

➡ CLOSE ADJUSTMENTS

A conveniently accessible adjustment ring provides for infinitely close adjustment—in ROCKFORD Over-Center CLUTCHES—without special tools. Fine adjustments can be made, and automatically maintained, without releasing or engaging separate locking devices which formerly limited adjustments to the spacing of notches or holes. This is but one of several exclusive features of ROCKFORD Over-Center CLUTCHES.

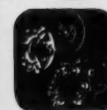
SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

ROCKFORD Clutch Division BORG-WARNER

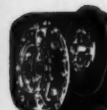
316 Catherine St., Rockford, Ill., U.S.A.

Export Sales: Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES



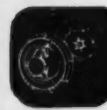
Small
Spring Loaded



Heavy Duty
Spring Loaded



Oil or Dry
Multiple Disc



Heavy Duty
Over Center



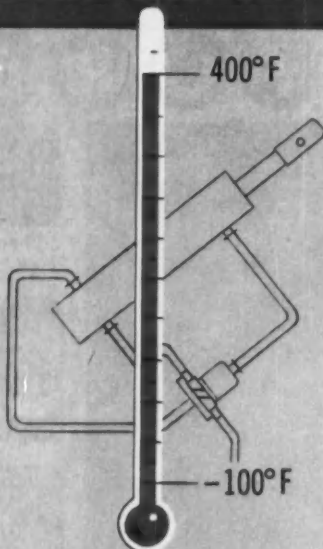
Power
Take-Offs



Speed
Reducers

Bendix
in Southern California

NEEDS HYDRAULIC DESIGNERS



One of the major programs at Bendix-Pacific is the long range development of high precision hydraulic controls for missiles and aircraft. We are seeking creative engineers familiar with high temperature requirements who are interested in pioneering the new frontiers.

Bendix-Pacific is one of the largest and best equipped sources for hydraulics in the nation. You are sincerely invited to consider joining this forward looking company where you can enjoy all the advantages of Southern California living.

Please mail the coupon or write today.

W. C. Walker, Engineering Employment Mgr.
Pacific Division, Bendix Aviation Corp.
11628 Sherman Way, North Hollywood, Calif.

I am interested in hydraulic engineering.
I am a graduate engineer with _____ degree.
I am not a graduate engineer but have _____ years experience.

Name _____

Address _____

City _____ Zone _____ State _____

Applications Received

Continued

Grant, Mitchell Joseph Haddad, George E. Hamlin, Jr., Owen F. Keeler, Jr., H. R. Lippert, Charles E. Marceau, John W. McDonald, William Irvin Mittel, Ira W. Nichol, Fred G. Oblinger, Harry G. Pilarski, Jr., Gomer H. Redmond, Ron Rohloff, Walter Edward Tutak, Earl Chester White, Edward G. Zwiller, Donald J. Hoffman, Hans E. Kutscher, Robert G. Simpson, Nickolas P. Yonutas

Indiana Section

James T. Baker, Harry B. Hart, K. H. Hoffman, Attila Frank Jeney, Bonnie J. Marshchand

Kansas City Section

A. S. King, Carrol J. Warrell

Metropolitan Section

Nicholas P. Cassisi, Howard Lawrence Chane, Richard H. Coulton, Jr., Leslie d'Avigdor, D. F. Ferris, Pierre John Haan, William J. Kestermeier, Edward V. McAssey, Harry P. Schmidt, Jr., Paul M. Steginsky, John W. W. Sullivan, Raymond Warell, Oscar O. Cote, John D. Rugge, Jr.

Mid-Michigan Section

George W. Benjamin, Joseph F. Doerr, Ernest J. Ross, Jack F. Leach, Sr.

Milwaukee Section

John W. Boda, L. Robert Goldsworthy, Edward W. Kriesmer, Walter J. Mayer, Joseph F. Pech, Roy J. Rauchle, John F. Schaefer, James J. Sicotte, Daniel J. Wahlen, Cecil Joseph Paoletti

Mohawk-Hudson Section

Charles M. Chodash, John H. Rogers

Montreal Section

R. H. Bowden, James Henry Crook

New England Section

Ralph F. Cataldo, Thomas E. DeMont, Frank E. Harlow, Russell S. Rockafellow, William Waite

Northern California Section

George C. Jennings, Thomas Harold Riddle, James L. Smartt

Northwest Section

Douglas Bynum, Jr., William F. Hetrick, John C. Watson, Jr.

Ontario Section

Colin Campbell

Salt Lake Group

Guenter Kammer, Dieter K. Schmidt, Lionel George Wildey

San Diego Section

Robert P. Dodds, Floyd E. Zimmerman

South Texas Group

John W. Brooks

Southern California Section

Reginald B. Bland, Thomas Francis Dixon, Karl T. Edwards, David Ronald Lundquist, Henry Hector Porras, John Lee Rogers, George K. Tabata, James C. Walshe

Southern New England Section

Edward Lacey

Spokane-Intermountain Section

Fred N. Bock

Syracuse Section

Dan S. Tilden

Texas Section

Alfred Paul Brandimarte, Robert Walter Burden

Texas Gulf Coast Section

Dan W. McCants, R. L. Roshong, James E. Sadler

Twin City Section

Merrill Allyn Johnson

Virginia Section

Byrd F. Shrader

Washington Section

Richard H. Hawkes

Western Michigan Section

Lloyd Jones, Jr.

Wichita Section

Daniel Ernest LaMaster, Samuel Sanner

Williamsport Group

John T. Gibson, Kenneth B. Lawrence

Outside Section Territory

Alan Macdonald, Jr., Richard C. Snyder, Raymond T. Zwack, Newton N. Sacks

Foreign

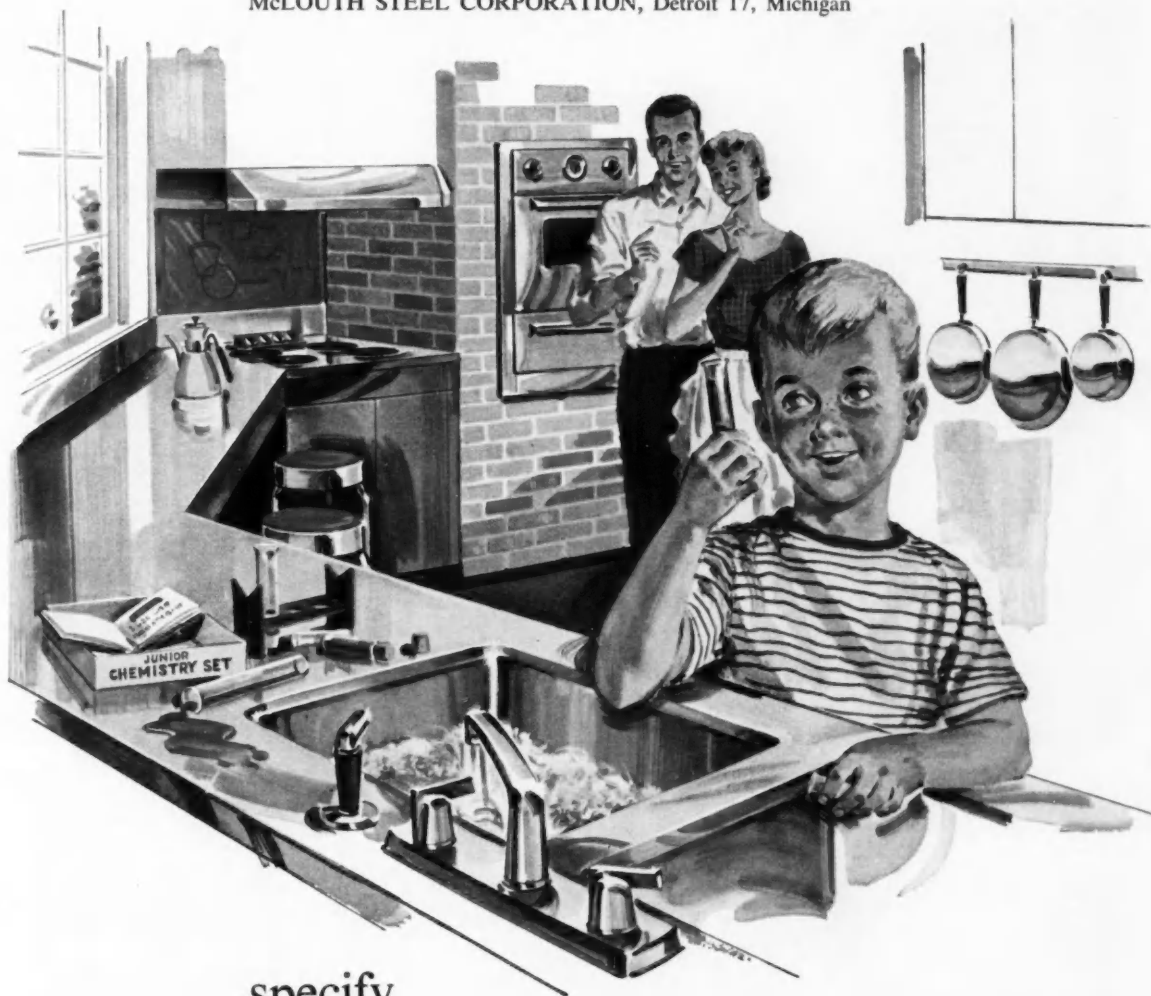
A. V. J. Fernandes, India; S. Shanmugasundaram, India; Kenneth Pearce Wakefield, England

carefree is stainless steel

The gleaming efficiency of Stainless housewares is a joy to every woman. Everything made of Stainless Steel cleans with ease, lasts a lifetime and brightens-up the home.

No other metal offers the freedom of design and fabrication, economy of care and the durable beauty that serves and sells like Stainless Steel.

McLOUTH STEEL CORPORATION, Detroit 17, Michigan



specify

McLOUTH STAINLESS STEEL

HIGH QUALITY SHEET AND STRIP

for homes and home products

... performance
beyond the
usual...

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- A broad range of types and sizes, numbered in the thousands
- Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction
- Crowned rollers
- Modification of any factor to meet your application

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.



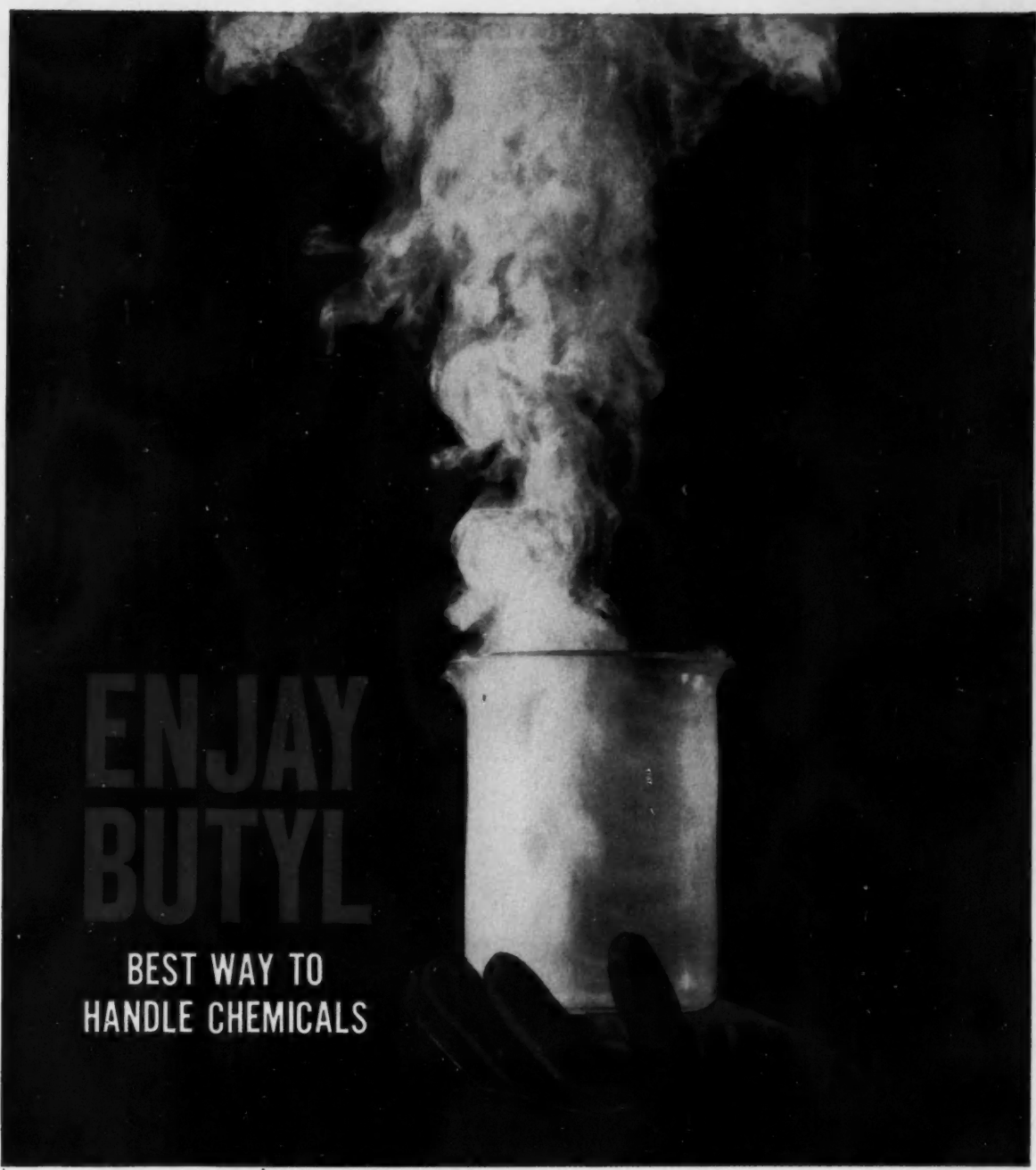
ROLLWAY
MAXIMUM
BEARINGS

ENGINEERING OFFICES

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Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto



ROLLWAY
Maximum
ROLLER BEARINGS



ENJAY BUTYL

BEST WAY TO
HANDLE CHEMICALS

Here are a few of the many chemicals that Butyl offers excellent resistance to:

Dimethyl hydrazine	Cl Br methane
Phosphoric acid	Ozone
Sulfuric Acid	Hydrofluoric acid
Red fuming nitric acid	Ammonia
Oxygenated solvents	Molten sulfur

Enjay Butyl rubber, due to its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. Versatile Butyl is the preferred rubber for countless types of hoses, tank linings, gaskets, seals—and many other applications where exacting chemical resistance is required.

Butyl also offers...outstanding resistance to weathering, sunlight, heat, and electricity...abrasion tear and flexing...superior damping properties...and unmatched impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

SAE JOURNAL, MAY, 1959



NOTABLE ACHIEVEMENTS AT JPL...

JPL PIONEERING CONTINUES WITH THE LAUNCHING OF THE FIRST SUCCESSFUL AMERICAN MOON PROBE

Early on March 3, 1959, Pioneer IV space probe was launched from Cape Canaveral, Florida to become America's first deep-space vehicle capable of escaping the earth's gravitational pull. On its way past the moon and out into orbit around the sun, this new man-made planet sent back valuable information on the radiations present in space. Several Free World tracking stations clearly

received its transmitted signal and helped to establish its distance, velocity, and direction.

Under the sponsorship of the National Aeronautics and Space Administration, JPL designed and built not only the conical payload of Pioneer IV but also the three upper stages of the Juno II launching vehicle, containing new high-performance JPL solid propellant rockets.

Over a year ago the same JPL team, in cooperation with ABMA, gave America its first earth satellite, Explorer I, using a similarly reliable vehicle—the Jupiter C.

Now, more advanced space vehicle programs are under way at JPL—programs which include development of guidance and propulsion systems for accurate maneuvers many million miles from the earth.



*The JPL tracking station at Goldstone
in the Mojave Desert in California*



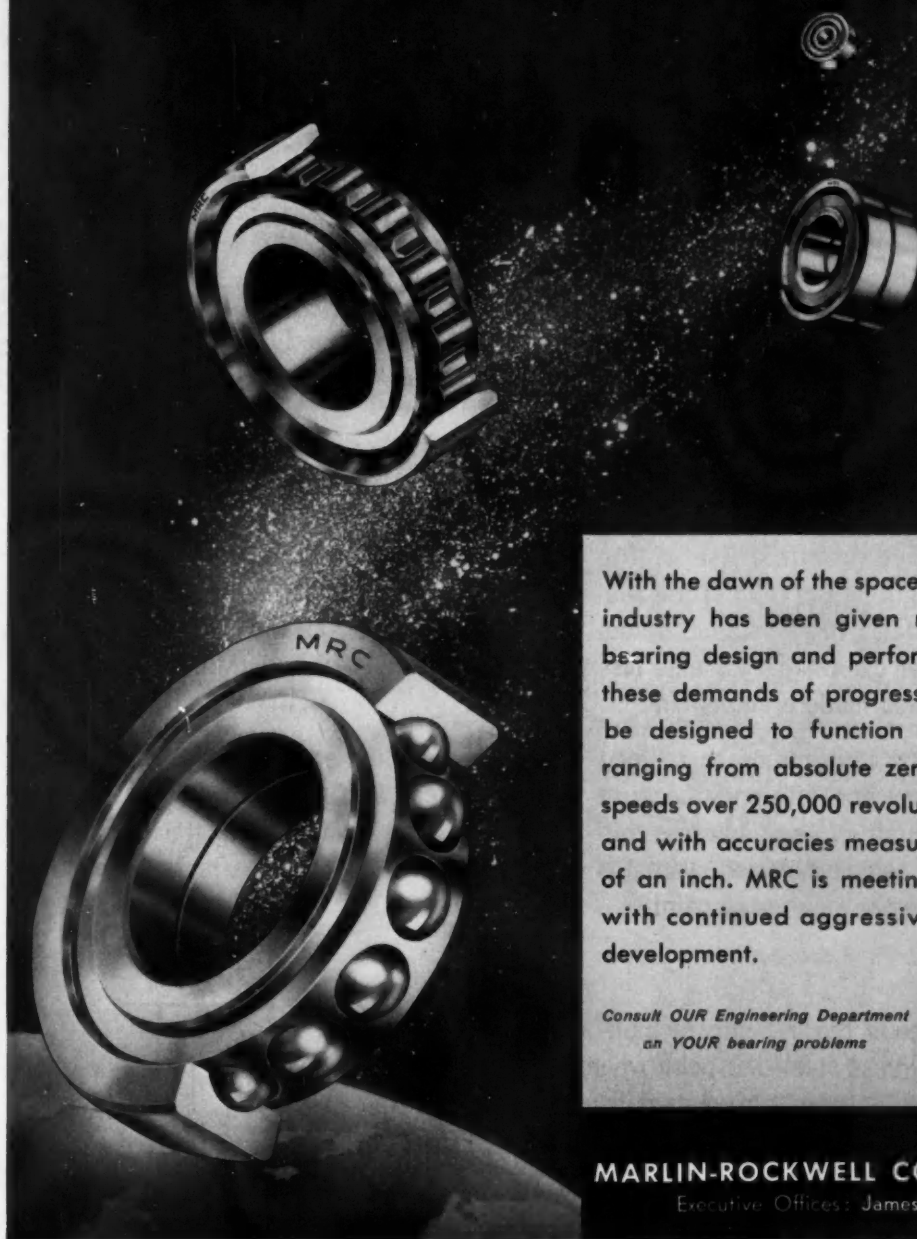
CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility of the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

OPPORTUNITIES NOW
OPEN IN THESE FIELDS

APPLIED MATHEMATICIANS • PHYSICISTS • SYSTEMS ANALYSTS • CHEMISTS • IBM-704 PROGRAMMERS
ELECTRONIC, MECHANICAL, CHEMICAL, PROPULSION, INSTRUMENTATION, MICROWAVE, AERONAUTICAL AND STRUCTURAL ENGINEERS

MRC

Super-Precision
BALL and ROLLER BEARINGS



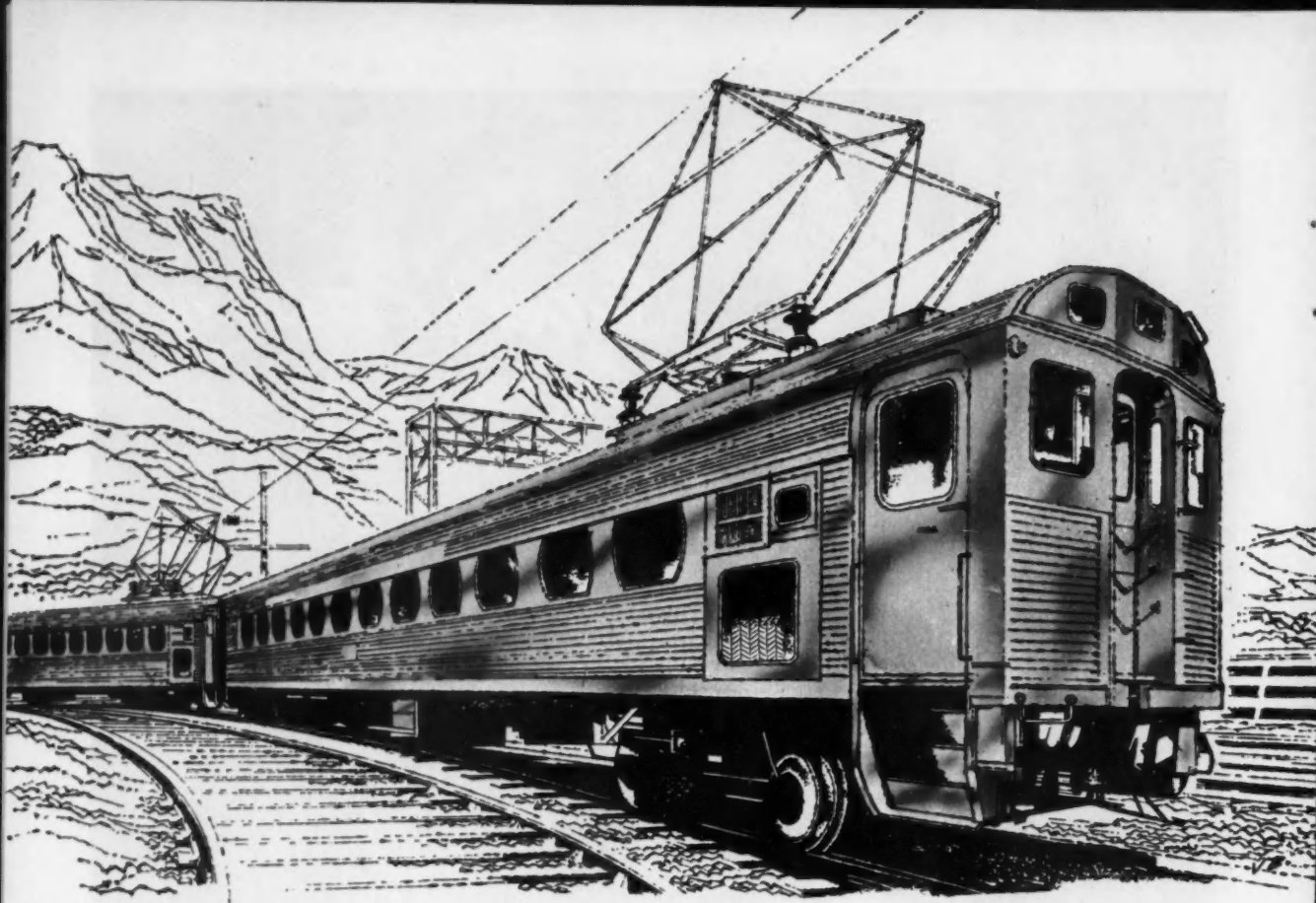
With the dawn of the space age the bearing industry has been given new frontiers in bearing design and performance. To meet these demands of progress, bearings must be designed to function in temperatures ranging from absolute zero to 2000°F; at speeds over 250,000 revolutions per minute and with accuracies measured in millionths of an inch. MRC is meeting this challenge with continued aggressive research and development.

Consult OUR Engineering Department
on YOUR bearing problems



MARLIN-ROCKWELL CORPORATION

Executive Offices: Jamestown, N. Y.



Light as a 128-Passenger Feather

Because it makes practical use of the remarkable strength-weight ratio of the austenitic stainless steels, this all-stainless steel railroad passenger car weighs **25 tons less** than other so-called modern equipment.

It is an important contribution to railroad operating economy and efficiency because its stainless steel structure guarantees millions of miles of service between overhauls—its gleaming exterior requires no paint.

Designed and built by The Budd Company, it is considered one of the greatest engineering achievements of the century—made possible **only** by that brawny beauty stainless steel.

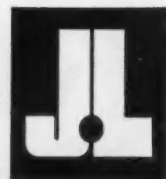
In your product engineering when weight is a problem and strength a necessity the answer can be found in stainless steel's unique combination of strength, durability and beauty.

J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, and engineering achievement begins.



Plants and Service Centers:

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STAINLESS

SHEET • STRIP • BAR • WIRE

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34



Smart move...choose...



Ross
STEERING



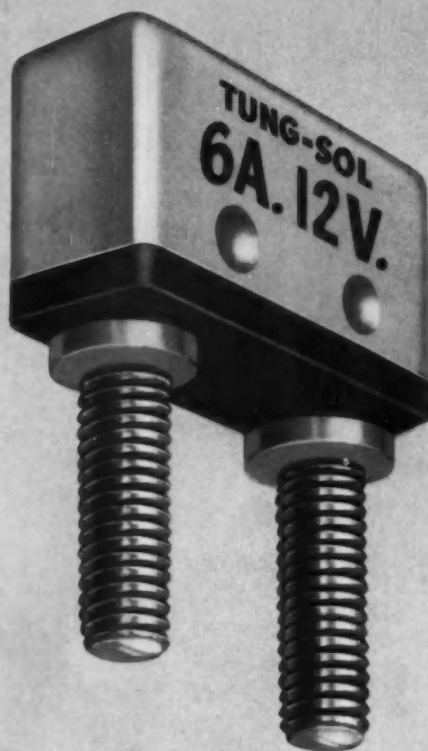
Passenger cars, trucks, tractors, buses, combines, cranes, earth movers, boats, fire engines, fork lifts, sweepers, scrapers, shovels; you name it . . . *all* rely on Ross for easy, safe, economical steering. Smart move, choose Ross for your steering needs.



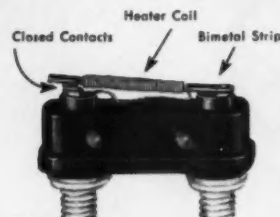
ROSS GEAR AND TOOL CO., INC. • LAFAYETTE, INDIANA
Gemmer Division • Detroit



Steering manufacturers for original equipment since 1906

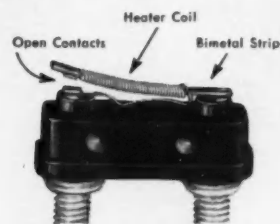


Method of Operation



NORMAL CONDITIONS

Current flows thru strip attached across breaker studs. When contacts are closed, heater coil is short circuited and has no heating effect.



EMERGENCY CONDITIONS

A short circuit or overload increases current. Causes strip to bend away from contacts. When contacts part, heated coil holds contacts open.

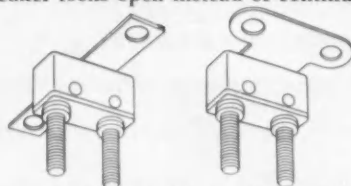
REMOTE RESET

means positive circuit protection

Here's complete protection against burned out accessory motors and wiring, damaged breakers and run-down batteries. When the circuit is overloaded or shorted, the Tung-Sol 12-volt remote reset circuit breaker locks open instead of continuing

to pulsate. When the cause of the overload or short is removed, the breaker is then remotely reset. It reactivates the circuit within 30 seconds.

Available in 6, 10, 15, 20, 30 and 40 amp. ratings with a choice of two standard mounting brackets, Tung-Sol remote reset circuit breakers are used in a wide variety of automotive applications. For further information write Automotive Products Division, Tung-Sol Electric Inc., Newark 4, New Jersey.



TWO STANDARD MOUNTING BRACKETS



TUNG-SOL®

REMOTE RESET CIRCUIT BREAKERS



EVERY BORG & BECK CLUTCH
MUST "WALK A STRAIGHT LINE"
TO ASSURE PERFECT BALANCE

Probably the most important single quality in a clutch is *balance*—because balance means smoothness of operation, not only of the clutch but of the engine as well.

That's why Borg & Beck clutches are checked for balance, at operational speeds, on specially designed test machines. Even the slightest unbalance is instantly detected and carefully corrected. Perfect balance is assured, as shown above, when the electric beam of the oscillograph is vertically straight on the calibrated screen. And every Borg & Beck clutch must "walk this straight line" before it passes inspection.

This is typical of the extra care that goes into every step in the making of Borg & Beck clutches. It is your assurance of top quality, top performance, top value.



Reg. U. S. Pat. Off.



BORG & BECK®

THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3



Acids, Beverages, Caustics, Dyes . . . everything goes in Stainless Steel tankers

*Cleanability of corrosion-resisting type 316 Stainless Steel
gives tank trailers great hauling flexibility*

Leave the home lot in the morning loaded with animal or vegetable oils, return in the evening with paint or varnish, and back on the road before daylight with a load of glue . . .

This is the kind of flexibility you can build into a tank trailer when you use type 316 Stainless Steel.

Its lasting resistance to corrosion means that many liquids—chemicals, foods, petroleum products — can be bulk transported in the same tanker. Usually, all that's needed to change

from one product to another is a quick, but thorough, cleaning job.


The corrosion-resisting quality of type 316 Stainless also boosts the service life of the tanker. One motor transport company reports that they bought their first stainless steel tanker 20 years ago and it's still in service.

**Easy to fabricate . . .
economical to produce**

The nickel content of 316 Stainless

Steel not only enhances the metal's corrosion resistance and durability, but also gives it unusual ductility and weldability . . . makes possible fast, simple fabrication . . . economical production.

If you would like more information about the superior corrosion resistance and fabricability of 316 Stainless Steel . . . as well as the specific properties and characteristics, just let us know. We'll answer any specific questions you have.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street  New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER



• The molding compound you see here is made by Federal Pacific Electric Company, at its Newark, N. J. circuit breaker plant. In changing over from a vendor supply system to *their own compounding shop* FPE saved enough on costs to amortize their \$100,000 equipment investment in ten months.

Federal Pacific manufactures a complete line of low and high voltage electrical distribution and control apparatus and uses Reichhold PLYOPHEN phenolic resin as their prime molding compound resin. Mr. R. B. Goody, in charge of plastics research, said "the basic properties of the PLYOPHEN material are improved by our formulating. *More resistance to voltage breakdown, better mechanical stability and higher impact range are achieved by doing our own compounding work.*

"Our selection of RCI as a prime supplier of molding resins was made after years of trying to work with ready-mixed molding compounds. When these compounds were supplied from several sources, we had trouble with fluctuating costs, erratic delivery schedules and varying

formula consistency. We finally decided we could simplify matters by installing our own compounding department.

"Working in close collaboration, engineering teams from both Reichhold and FPE developed a series of formulas which answered our needs."

Perhaps, you too can realize substantial savings by producing your own molding compounds with RCI Plyophen phenolic resins and with the help of RCI experts in resin technology. Contact your Reichhold representative for specific details.

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate
Sulfuric Acid • Methanol

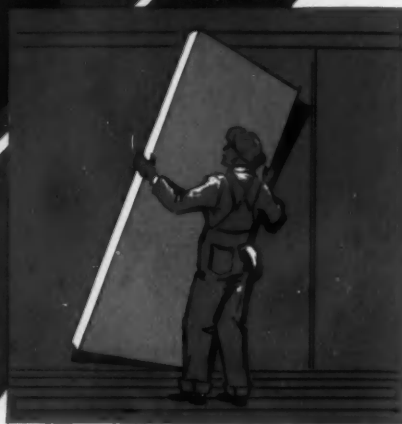
Creative Chemistry . . . Your Partner in Progress

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.



for economy operation
and increased payload
...specify the most
efficient insulation

Rigid Urethane Foam!



Here is a new kind of insulation, rated almost twice as efficient as the best competitive materials and more than *three to seven times* better than many others commonly used!

This means that lightweight rigid urethane foam gives you better insulation in lesser thicknesses to increase your payloads.

Insulation value remains high because rigid urethane doesn't pack down, doesn't deteriorate at high temperatures and has extremely low moisture gain. Modular panel sandwich construction minimizes air leaks and eliminates through-bolt heat transfer. Panels are economical to install and easy to replace in road emergencies.

As producers of NACCONATE® Diisocyanates, essential urethane chemicals, we are working with body builders and insulation manufacturers as well as conducting independent research in this important application. We will gladly put you in touch with competent sources of supply.

NATIONAL ANILINE DIVISION

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Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form a bond which was stronger than the hose itself.

If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

Eastman
first in the field

MANUFACTURING COMPANY
Dept. AE-5
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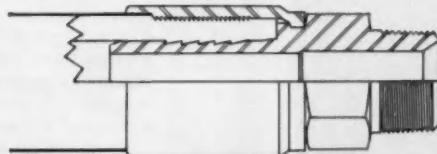
WRITE today for your copies —

Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.

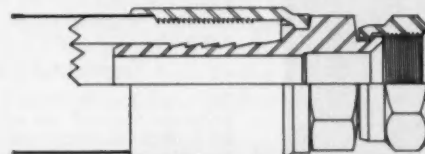
SAE JOURNAL, MAY, 1959

MALE NPTF



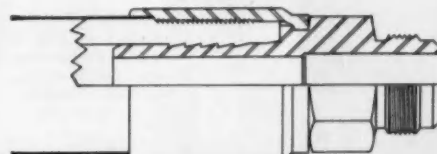
Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12M	3/4	1 1/4	1 1/2	20,000	5,000
8416-16M	1	1 3/4	2 1/2	16,000	4,000
8420-20M	1 1/4	2	2 3/4	12,000	3,000
8424-24M	1 1/2	2 1/2	3 1/4	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12FH	3/4	1 1/4	1 1/2	20,000	5,000
8416-16FH	1	1 3/4	2 1/2	16,000	4,000
8420-20FH	1 1/4	2	2 3/4	12,000	3,000
8424-24FH	1 1/2	2 1/2	3 1/4	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12MH	3/4	1 1/4	1 1/2	20,000	5,000
8416-16MH	1	1 3/4	2 1/2	16,000	4,000
8420-20MH	1 1/4	2	2 3/4	12,000	3,000
8424-24MH	1 1/2	2 1/2	3 1/4	10,000	2,500



Controls & Instrumentation Engineers

Marquardt Aircraft—a leader in air and space propulsion and control systems, high altitude rocket research and weapon support systems—offers a creative engineering environment in which you will find significant active projects. These include engine control systems for nuclear turbojet, inlet control systems for the North American F-108 and Hound Dog missile, control systems for the supersonic ramjet engine, feasibility studies of advanced and unique engine cycles, nozzle control for advanced ballistic missile components and other power system actuators. These control units include fluid and gas operated servo systems suited for environments above one thousand degrees.

If you are an engineer experienced in fluid dynamics or fluid operated controls and interested in mechanisms designed for severe environmental conditions, you should consider one of the following engineering opportunities at Marquardt:

CONTROLS DESIGN

To create components for pneumatic and hydraulic control systems. Work ranges from simple piston actuators to complex speed computing devices. All designed for high sensitivity, fast response, extreme environmental conditions and light weight. Should be experienced in machine design and have an understanding of basic design analysis.

CONTROLS ANALYSIS

To investigate aircraft and missile control problems through the application of analysis methods in mechanics and dynamics, heat transfer, compressible flow, and servomechanisms. Position offers opportunity for creative engineering.

CONTROLS DEVELOPMENT

Opportunity to create workable controls components. Must have a "feel" for hardware and desire to undertake broad engineering responsibility. Opportunity to solve "on-the-spot" engineering problems utilizing pneumatic and hydraulic control analysis techniques.

ENGINEERING STANDARDS

Implement, establish and/or originate the use of standards both design and hardware for reduction of time and cost of engineering effort. Must have knowledge of hydraulic and pneumatic design and components. Should be capable of setting up an evaluation program as required. Requires ability to work with many engineering groups both in advisory and service capacity.

CONTROL RELIABILITY

To predict reliability of control of units and recommend appropriate design changes. Knowledge of servomechanisms and feedback theory desirable. Should have background in statistics and experience in reliability field.

INSTRUMENTATION

Specification and design of instrument components and systems for ground testing of supersonic ramjet engines, jet engine components, inlet controls, nuclear powerplant controls and emergency power units. Prefer instrumentation experience, including data acquisition and processing equipment. Familiar with process control systems.

For additional information, please write

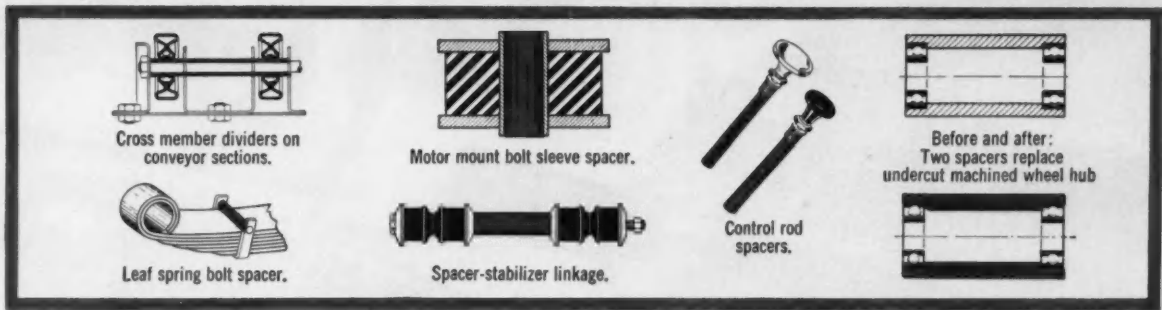
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Professional Personnel, Dept. 1-1
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Van Nuys, California

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**Time, Money, Materials with
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Spacers can effect savings in many manufacturing and assembly operations—from automobiles to pull toys, phonographs to corn pickers. Furnished to your exact dimensions, ready to assemble, they are an economical substitute for iron pipe, tubing or machined parts; eliminate

costly cut-off and de-burring machine time; save on secondary operations such as slots, holes, notches and chamfers. In steel, aluminum and stainless. Plain or plated. Many lengths, diameters and wall thicknesses. Complete engineering service.

FREE design data book on standard and special spacer specifications. Address:

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THERE'S A VERSATILE SAGINAW SCREW TO SOLVE EVERY ACTUATION PROBLEM

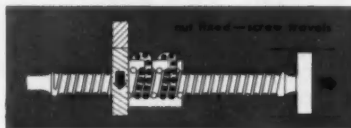
ACTUATES and POSITIONS WITH OVER 90% EFFICIENCY

- **POSITIONS MORE PRECISELY** than acme screws, hydraulics or pneumatics. Can be held within .0005 in./ft. of travel.
- **SAVES POWER** with over 90% efficiency. Permits much smaller motors, far less power drain, simplifies circuitry.
- **SAVES SPACE/WEIGHT** because Saginaw b/b Screws are compact. Allows smaller, lighter motors, gear boxes. Eliminates cumbersome auxiliary equipment.
- **DEPENDABLE PERFORMANCE.** Saginaw Screws are far more reliable than hydraulics. Gothic-arch grooves, yoke deflectors, multiple circuits increase assurance.
- **TEMPERATURE TOLERANCE.** Normal operating range is from -75°F . to $+275^{\circ}\text{F}$. With selected materials, up to $+900^{\circ}\text{F}$.
- **LUBRICATION LATITUDE.** If lube fails, the Saginaw b/b Screw still functions with remarkable efficiency.

The men who want to exact the maximum potential from their products specify the remarkable Saginaw Screw! The unequalled efficiency and precision of the Saginaw b/b Screw goes a long way to eliminate design and production problems. It actuates your product (large or small) more smoothly, simply, surely, and very often more cheaply than other methods. For full details, write or phone today for your free 1959 engineering data book on Saginaw b/b Screws and Splines.

A FEW TYPICAL USES OF SAGINAW SCREWS:

- Airplane & Missile Components
- Photography Equipment
- Bumper Jacks and Lift Trucks
- Convertible Top Lifts
- Automatic Garage Doors
- Circuit Breakers
- Die Table Positioners
- Farm Equipment and many, many other applications



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.



WORLD'S MOST
EFFICIENT
ACTUATION DEVICE

Saginaw  **Screw**

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN

WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

At Boyertown
Auto Body Works,
Youngstown Yoloy
"E" Sheets are being
fabricated into body
sections for their
commercial truck line.



Accent on Excellence

Youngstown Yoloy "E" sheets



True value in Boyertown bodies is the trouble-free, year-in, year-out service they provide. It's a value that starts with skilled craftsmanship—using only the best raw materials available.

Boyertown Auto Body Works, Boyertown, Pa., specifies Youngstown Yoloy "E" Hot and Cold-Rolled Sheets as basic material for both the outside and inside panels, as well as for certain structural frame members such as rear corner posts and roof crowns, of their delivery truck line. They've found this versatile steel's high strength-low weight ratio allows design of higher payload vehicles.

Wherever high-strength steel becomes a part of things you make, the high standards of Youngstown quality, the personal touch in Youngstown service will help you create products with an "accent on excellence".



Youngstown
Youngstown, Ohio

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Carbon, Alloy and Yoloy Steel



Send for free technical
bulletin on Youngstown
Yoloy "E" Steel.

DON'T

HOPSCOTCH

**for
quality in
leather
packings!**

There are a lot of variables in the proper selection of leather for packings or oil seals. For example, what section of the hide is best for your application? . . . How should it be tanned? . . . Impregnated? . . . Designed? . . . Molded?

The "custom" approach is used by IPC for leather and synthetic packings. Let IPC "in" on your problem. Our experience and attention to detail can give you a winner on your first try. It pays to do business with specialists.



OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed
... for your application



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Bristol, New Hampshire

P4



STEEL TUBING TIPS:

HOW TO SAVE MONEY WITH TUBING CUSTOM-MADE TO YOUR SPECIFICATIONS!



Millions of feet of GM Steel Tubing have been manufactured at Rochester Products. Modern up-to-date mass-production facilities and procedures assure the most efficient and economical results from your tubing dollar.

Select a plant with ample space and facilities for initial savings! Extensive plant facilities at Rochester Products are available to produce GM Steel Tubing tailored to your exact specifications in any quantity, any shape or form. Mass-production schedules can be established quickly, using existing equipment, at a substantial saving in time and money.

Ask Tubing Engineer to help cut costs at the planning stage. A GM Steel Tubing Engineer can recommend the best and most economical means of satisfying your specifications on existing high-production manufacturing equipment. His knowledge of industry developments can help make further savings in tubular refrigeration components and still retain maximum efficiency.

Enjoy the advantage of advanced forming equipment for further savings. Exclusive multiple bending equipment rapidly forms GM Steel Tubing serpentine to cut production time and costs. And further fabrication for secondary bends, scoring of tubing break-off, swaging, flaring or bending is also available on automatic equipment.

Benefit from quality controls that eliminate costly warranty losses. All bulk coils of GM Steel Tubing are high-pressure tested and cleaned to many times beyond specifications. Also, all fabricated serpentine are individually tested with 300 lbs. of dry air to assure further dependability.

Call your GM Steel Tubing Sales Engineer or write to: Tubing Sales Manager, Rochester Products Division of General Motors, Rochester, New York.

**Combine the economy of steel
with extensive plant facilities,
advanced forming equipment
and exclusive testing procedures**



Exclusive testing... solvent is introduced under pressure to... tubing, checking structural strength and giving you the cleanest tubing you can buy.



STEEL TUBING BY



**ROCHESTER
PRODUCTS**

DIVISION OF GENERAL MOTORS
ROCHESTER, NEW YORK

NEW!

SMALL!

DELCO POWER TRANSISTOR

*Designed
for use
where space
and weight
are
restricting
factors*



MAXIMUM RATINGS	2N1172
Collector Diode Voltage	40 volts
Emitter Diode Voltage	20 volts
Collector Current	1.5 Amperes
Junction Temperature	95°C
TYPICAL CHARACTERISTICS (25°C)	
Typ. Collector Diode Current I_{c0} $V_{cb} = 40$ volts	50 μ
Current Gain ($V_{ce} = -2$ volts, $I_c = 100$ Ma)	70
Current Gain ($V_{ce} = -2$ volts, $I_c = \frac{1}{2}$ A)	30
Saturation Resistance	0.3 ohms
Cutoff Frequency (Common Emitter)	17 kc
Thermal Resistance	12° C/Watt

The 2N1172 is a medium power transistor offering dependable operation in a new range of applications where space and weight have been a problem.

It's a mighty mite with more punch in a smaller package. The 2N1172, excellent for output use or as a driver for a very high power transistor, has already proved especially effective in DC amplifiers, voltage regulators, and as a driver for a high power stage in servo or other amplifiers.

This PNP germanium transistor is housed in a modified version of the JEDEC 30 package with a diamond shaped base for improved thermal conduction. It dissipates up to 2 watts at a mounting base temperature of 70 degrees centigrade. Available now in volume production—write today for complete engineering data.

DELCO RADIO

Division of General Motors
Kokomo, Indiana

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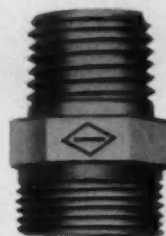
Engineering and Data File



ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS

Comparative Vibration Test Results

NUMBER OF VIBRATIONS IN CYCLES									
100,000	200,000	300,000	400,000	500,000		1,000,000			20,000,000
Flare Fitting failed after 72,450 cycles									
Compression Fitting failed after 79,350 cycles									
FLEX FITTING showed no signs of failure after ... 21,424,500 cycles									



Flex tube fittings withstand over 20-million cycles of vibration without failure

To cope with major vibration in fuel, oil, and vacuum lines serving cars, buses, tractors, trucks, and power units — nonrigid tube connections are preferred. Imperial Flex tube fittings have been proven to withstand over 20-million cycles of vibration without failure! (See bar graph above.)

Such top operating dependability is but one of the money-saving advantages of Imperial Flex fittings. These fittings also eliminate costly flexible hose lines except where there is extensive tube movement.

Design engineers point out that tube failure is caused by fracture due to metal fatigue and crystallization — a result of constant shock and vibration. Another cause for failure is tube distortion in making the connection.

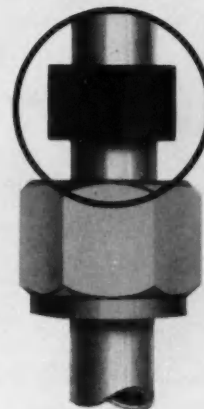
ELASTIC SLEEVE — To overcome these and other rigid fitting joint handicaps,

Imperial designed an elastic sleeve to cushion and absorb vibration. This special synthetic sleeve permits the tube to flex back and forth while continuing to maintain a positive, pressure-tight seal.

These reliable Flex fittings can be used for connecting all types of seamed and seamless metal tubing: copper, aluminum, thin-wall steel (such as Bundy or GM), Monel, stainless steel, Everdur and many others.

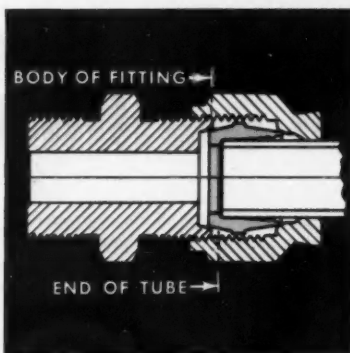
EASY INSTALLATION — To install Imperial Flex fittings for tubing $\frac{1}{2}$ " O.D. or smaller, just slip nut and flex sleeve over tubing. Insert tubing in fitting body as far as it will go and assemble. Positive stop nut prevents over-tightening.

Write for Catalog No. 344



No metal-to-metal contact with Imperial Flex fittings! Husky, resilient sleeve (encircled) withstands gas and oil ... flexes perfectly in sub-zero to 250° F. temperatures. For $\frac{1}{8}$ " to $\frac{3}{8}$ " O.D. tubing.

Imperial Hi-Seal tube fitting design offers greater reliability, simplifies installation of hydraulic systems



Butt-joint simplifies installation. Tube doesn't enter body of fitting. It bottoms on shoulder of sleeve. No tube torquing when making joint.

The superior design of Imperial Hi-Seal tube fittings pays off in reliability, simplified tube connections and reduced assembly time.

With Hi-Seal, the tube *does not* enter body of the fitting — it bottoms on shoulder of the sleeve. No need to spring tubing. Closer tube bends are possible — no flaring or threading is necessary. Joints stay pressure-tight beyond the burst strength of the tubing itself!

Hi-Seal tube fittings are available in brass, steel and stainless steel, for $\frac{1}{8}$ " to $1\frac{1}{2}$ " O.D. tubing. Long dryseal pipe threads are provided on all pipe ends.

Write for Bulletin No. 3061



Hi-Seal conforms to J.I.C., A.S.M.E. and A.S.A. standards.

CONTACT YOUR IMPERIAL REPRESENTATIVE OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. SAE-59, 6300 W. Howard St.
Chicago 48, Ill.

Please rush me:
☐ Bulletins ☐ No. 344 ☐ No. 3061

Name

Title

Company

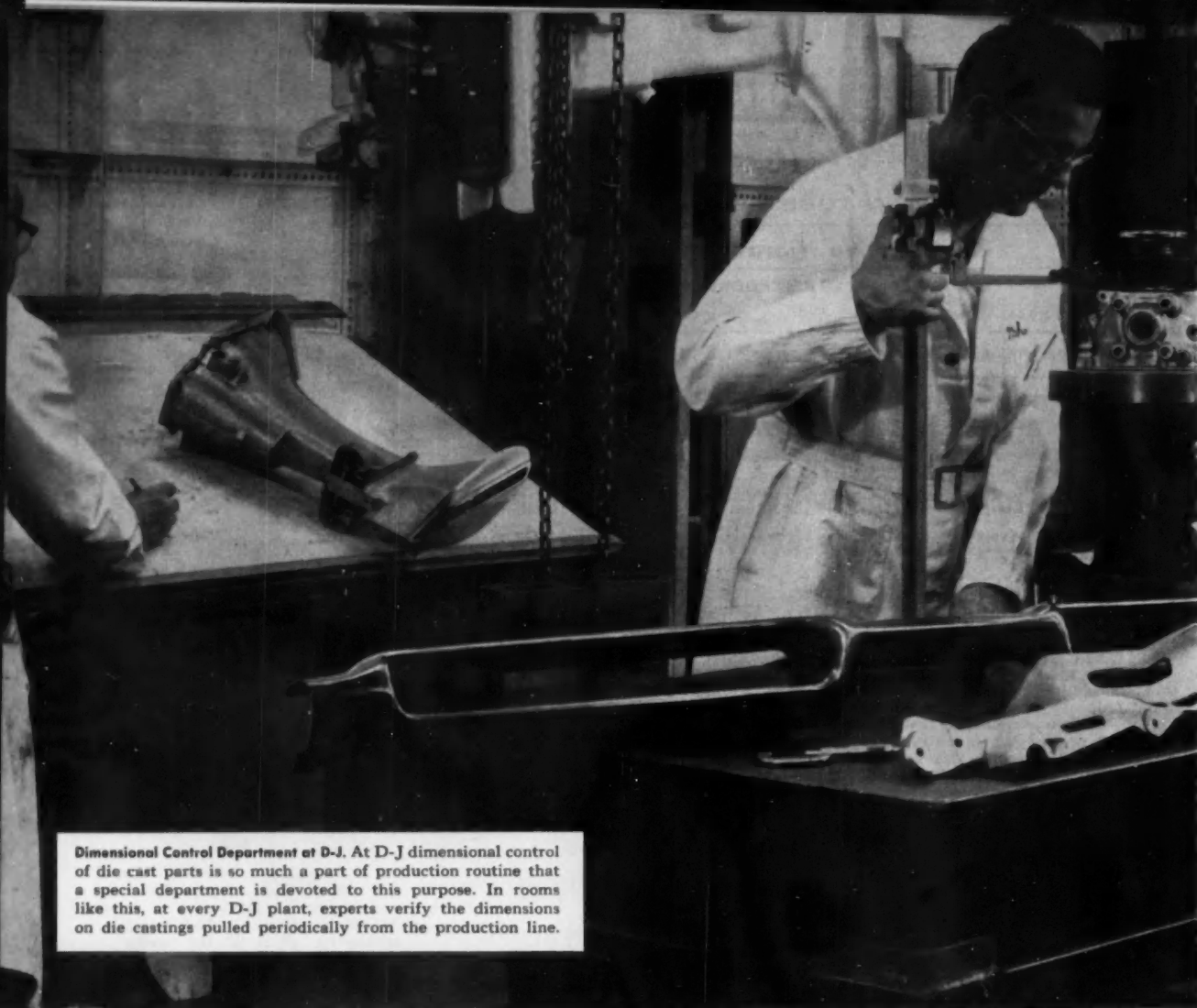
Street

City Zone State

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Illinois
In Canada: 18 Hook Ave., Toronto, Ontario





Dimensional Control Department at D-J. At D-J dimensional control of die cast parts is so much a part of production routine that a special department is devoted to this purpose. In rooms like this, at every D-J plant, experts verify the dimensions on die castings pulled periodically from the production line.

Outboard motor housing

Instrument panel bezel

Single cylinder engine block
Pinspotter part

At Doehler-Jarvis . . . everything improved production methods



Only a handful of companies have ever taken *full* manufacturing advantage of the inherent opportunities presented by the purchase of die castings — opportunities to so design parts that production *all along the line* is simplified, speeded up, and made more economical.

Frequently die castings are bought under conditions where price is the dominant

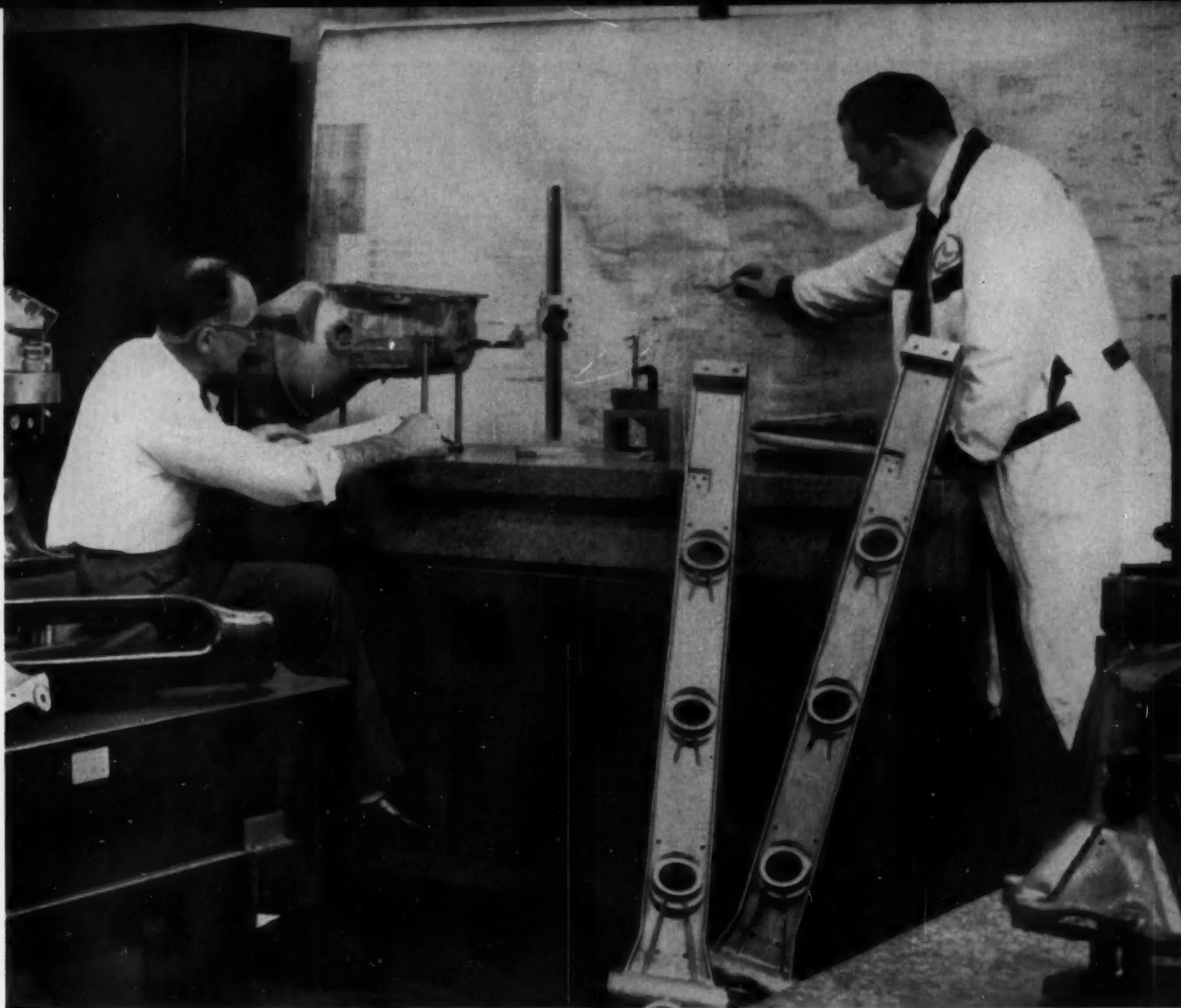
Automatic transmission parts illustrate how much can be done with die cast design. Notice the ganged fluid passageways. Not apparent, but incorporated into the design of each of these parts, are many features that make these parts usable much as they are . . . with a minimum of further manufacturing needed.

competitive factor. This approach sometimes makes good purchasing sense. And on the basis of price competition Doehler-Jarvis produces and sells more die castings per year than any other custom die caster.

But there is another, and often more rewarding, way to look at the purchase of die cast parts.

In many instances — most, in fact — a careful analysis of the part by experienced metal production men working in close coordination with equally experienced designers of the dies and the castings reveals ways to:

(1) reduce cost or improve performance of the casting itself.



Transmission housing

Pinspotter arms

Transmission p

needed to help you develop with the help of die castings

(2) introduce design features that eliminate one, many, or all of the machining, finishing or sub-assembling operations that must be accomplished before the part can be incorporated into the end product.

For example. Product engineers have only begun to realize the full range of applications made possible by the high fatigue strength inherent in aluminum die castings . . . by integrating several separate parts into one die casting . . . by ganging fluid passageways (as in automatic transmission designs).

Doehler-Jarvis customers who have taken this suggested broad viewpoint in purchasing their die castings find it pays off . . . sometimes enormously.

No producer of die castings can contribute more to this broad purchasing concept than Doehler-Jarvis.

In any category you care to name . . . research support . . . design help . . . skilled workmanship . . . versatility of metal working equipment (you can even buy *forgings, extrusions and stampings* from D-J) . . . sub-assembly facilities . . . choice of die casting metals and alloys . . . location of plants . . . delivery . . . Doehler-Jarvis provides more facilities than any other producer of die castings.

See what Doehler-Jarvis can do to help you realize the full potentials in die cast parts production. Call us in at an early stage in the design of your next new product or model change.

Doehler-Jarvis

Division of

NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

Barber Die Casting Co., Limited
Hamilton, Ontario



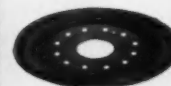
VALUE ANALYSIS where it really counts ... during design!



C/R Shaft Type Oil Seal



C/R Standard End Face Seal



C/R Sirvene Diaphragm



C/R Sirvis Molded Cup



C/R Rawhide Beveled Gear

Here's an expert at work, saving you money at the right time — during design. Like all C/R sales engineers, he's an experienced, well-trained representative whose knowledge springs from a solid engineering background. His ability to sit down with you during the design phase will help develop the most efficient and economical solutions to your problems.

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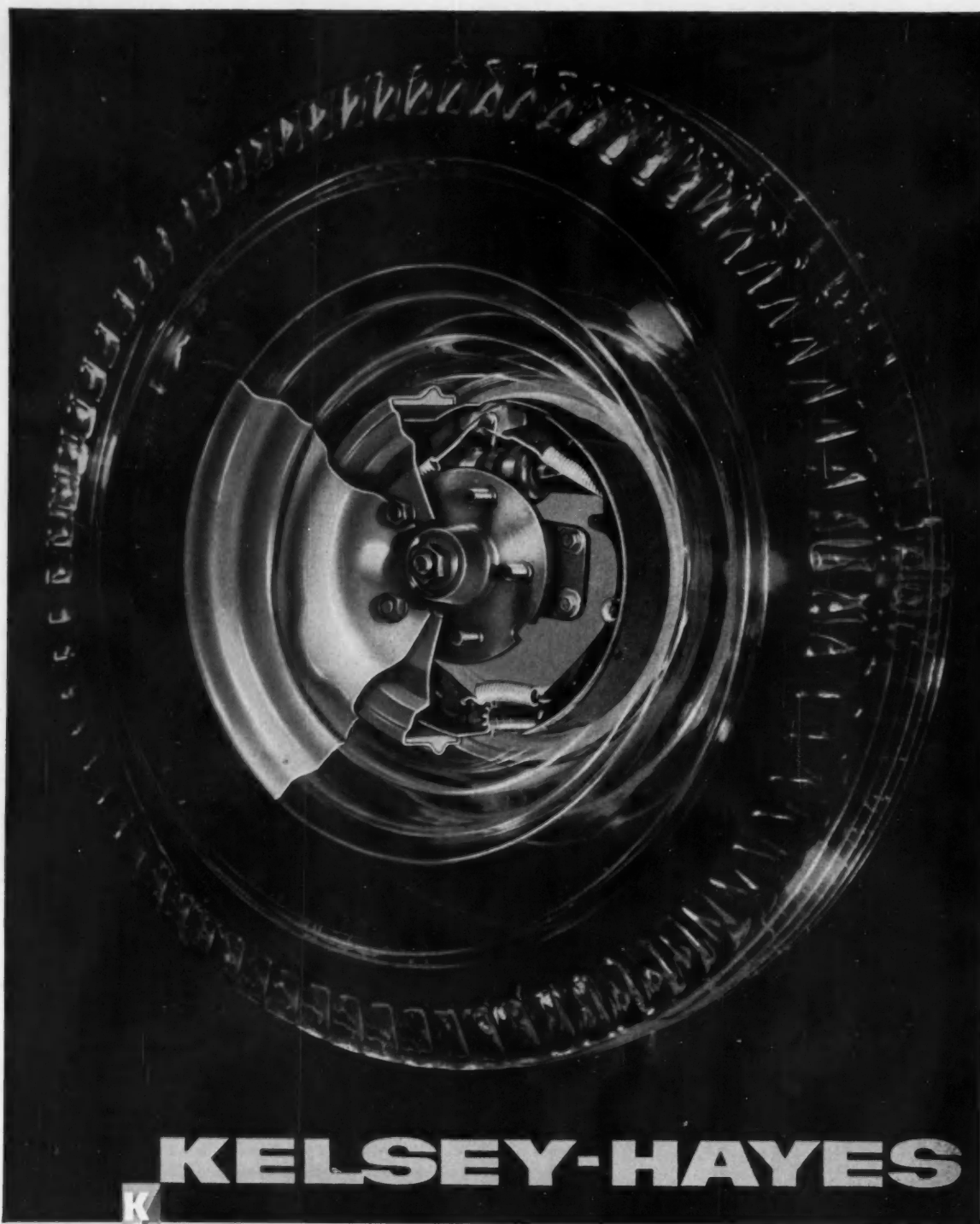
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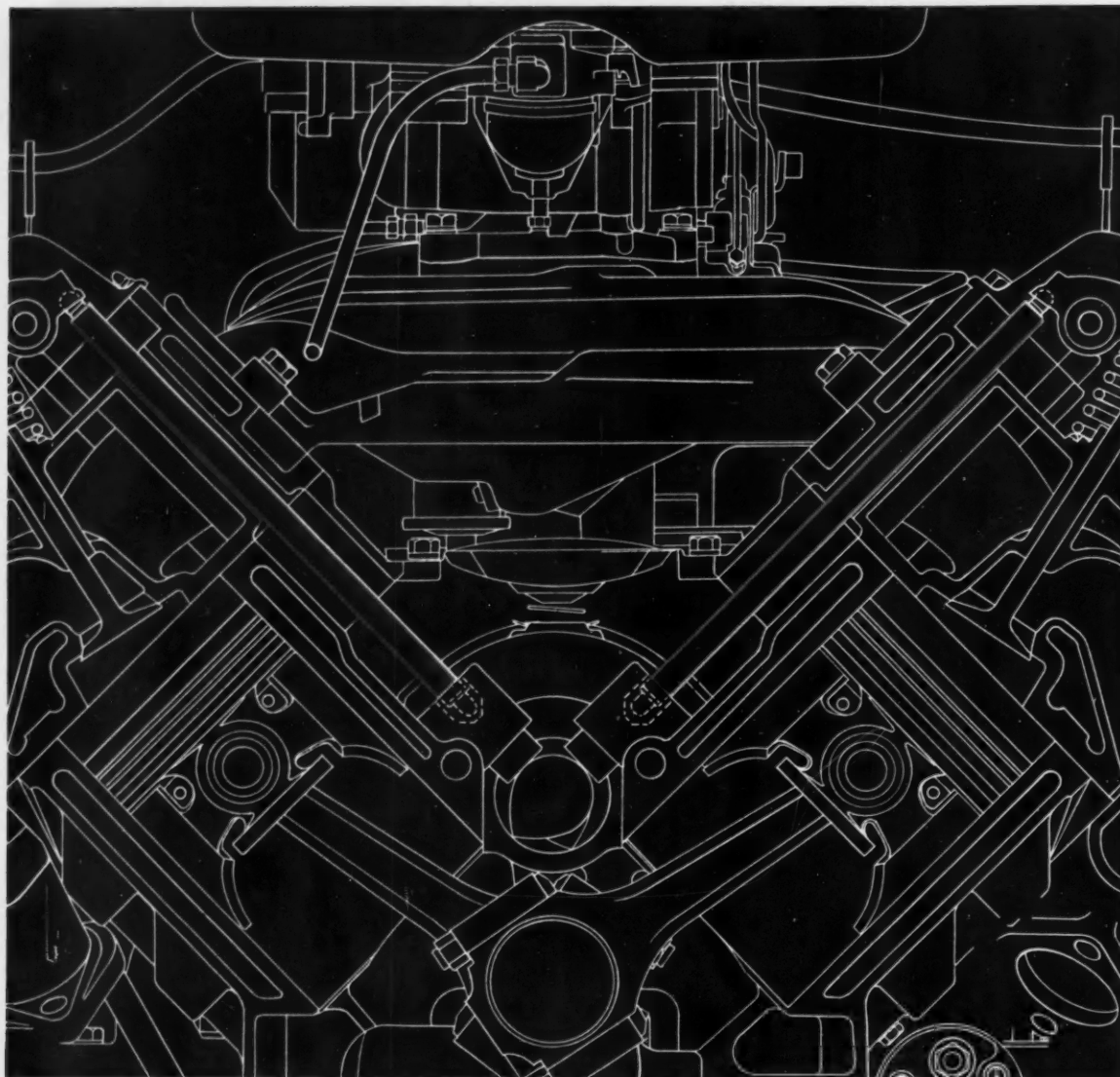


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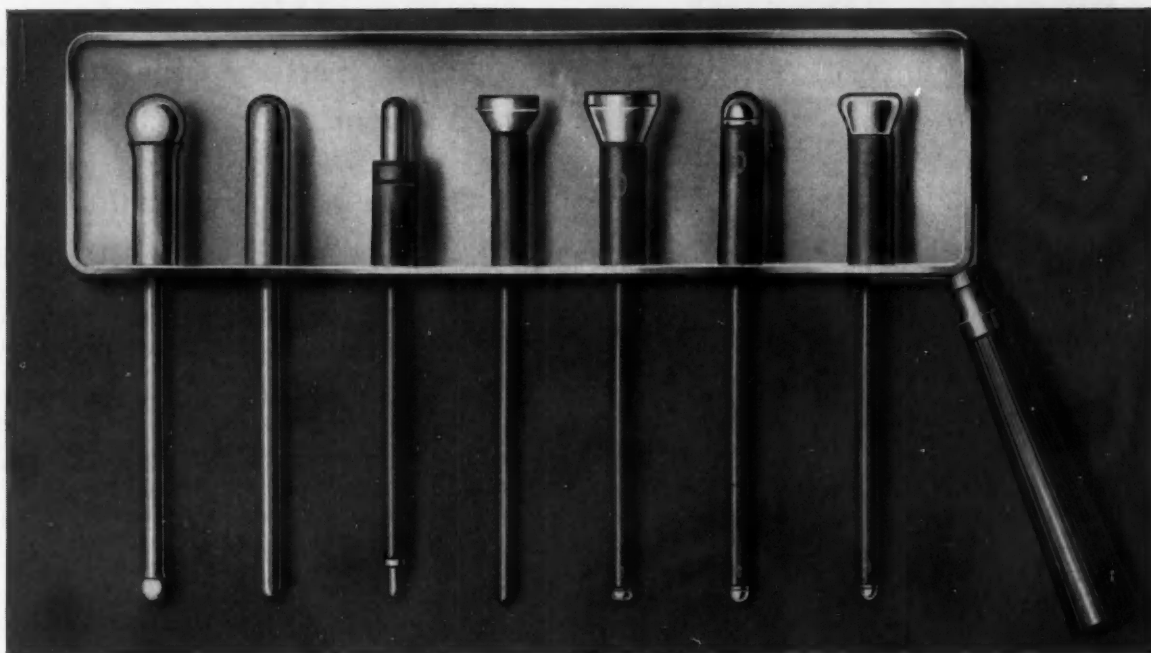
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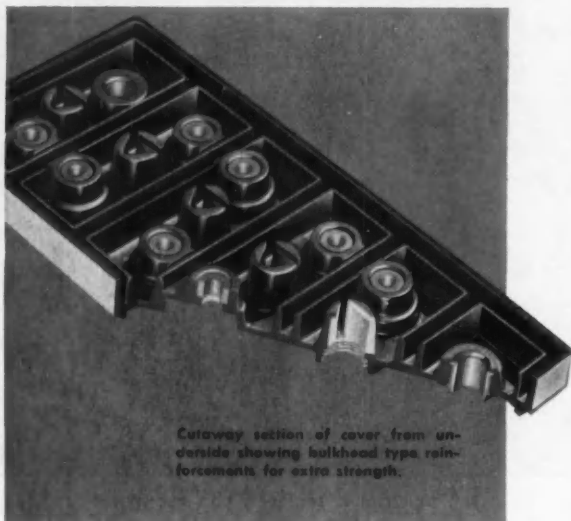
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Cutaway section of top showing one-piece construction, Grip-Ridge and groove for tongue-in-groove joint.



Cutaway section of cover from underside showing bulkhead type reinforcements for extra strength.

- Extra battery capacity
- Greater all-over container strength
- Better looking batteries

Pioneering the one-piece battery cover, Globe research achieved two significant advances:

1) A stronger, better performing battery with broader power range and longer life. One-piece cover with tongue and groove construction is weld-sealed to the case to make one inseparable unit. Cell partitions and container are reinforced like a battleship to withstand extreme heat and road-shock abuse.

2) More merchandisable battery. Construction permits Grip-Ridge for quickly anchoring Globe battery into battery carrier (any size). Unitized case has modern styling, permits painting in vivid color combinations for trade-up eye-and-buy appeal.

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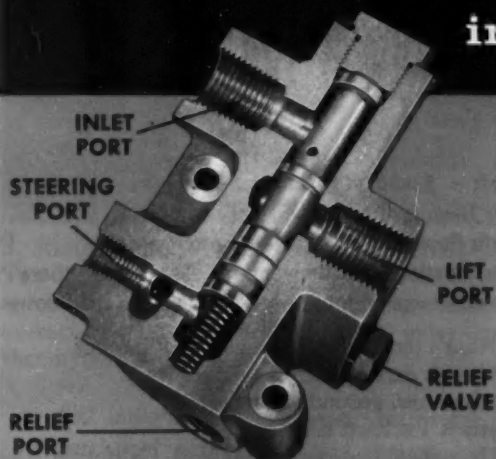
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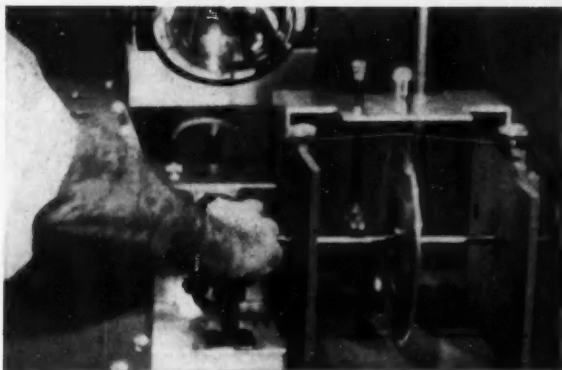
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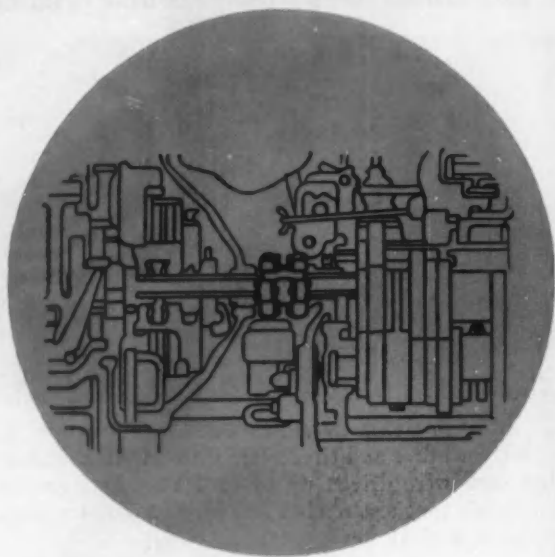
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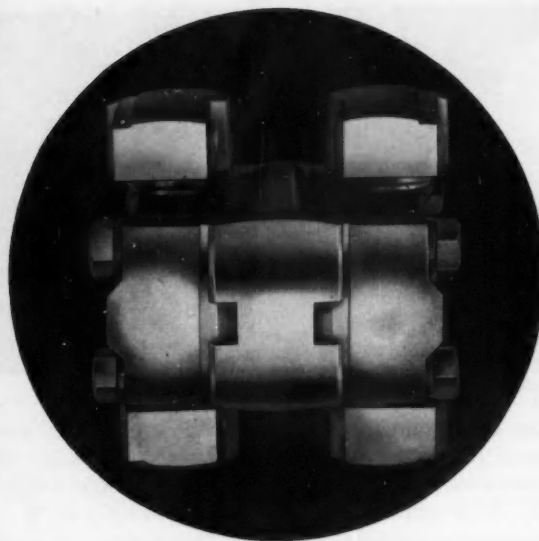
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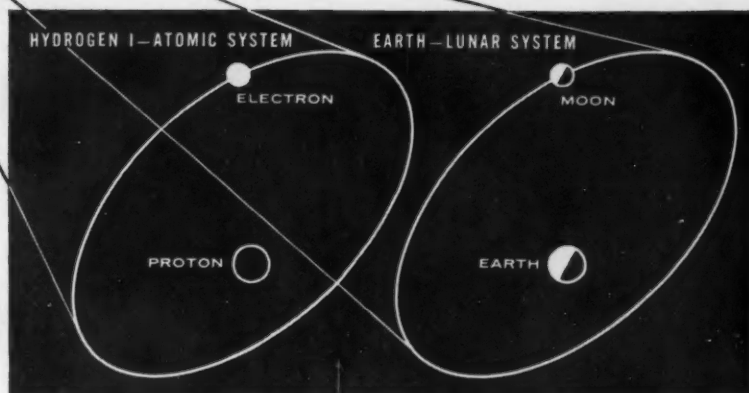


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MECHANICS UNIVERSAL JOINT DIVISION

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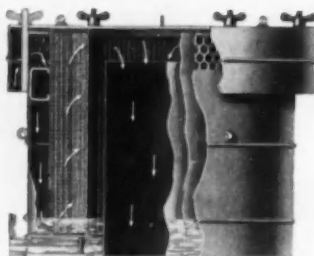
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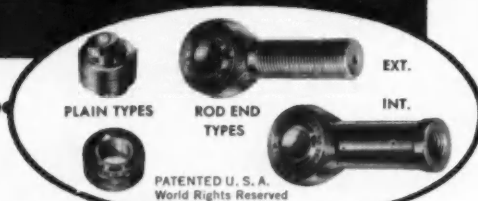
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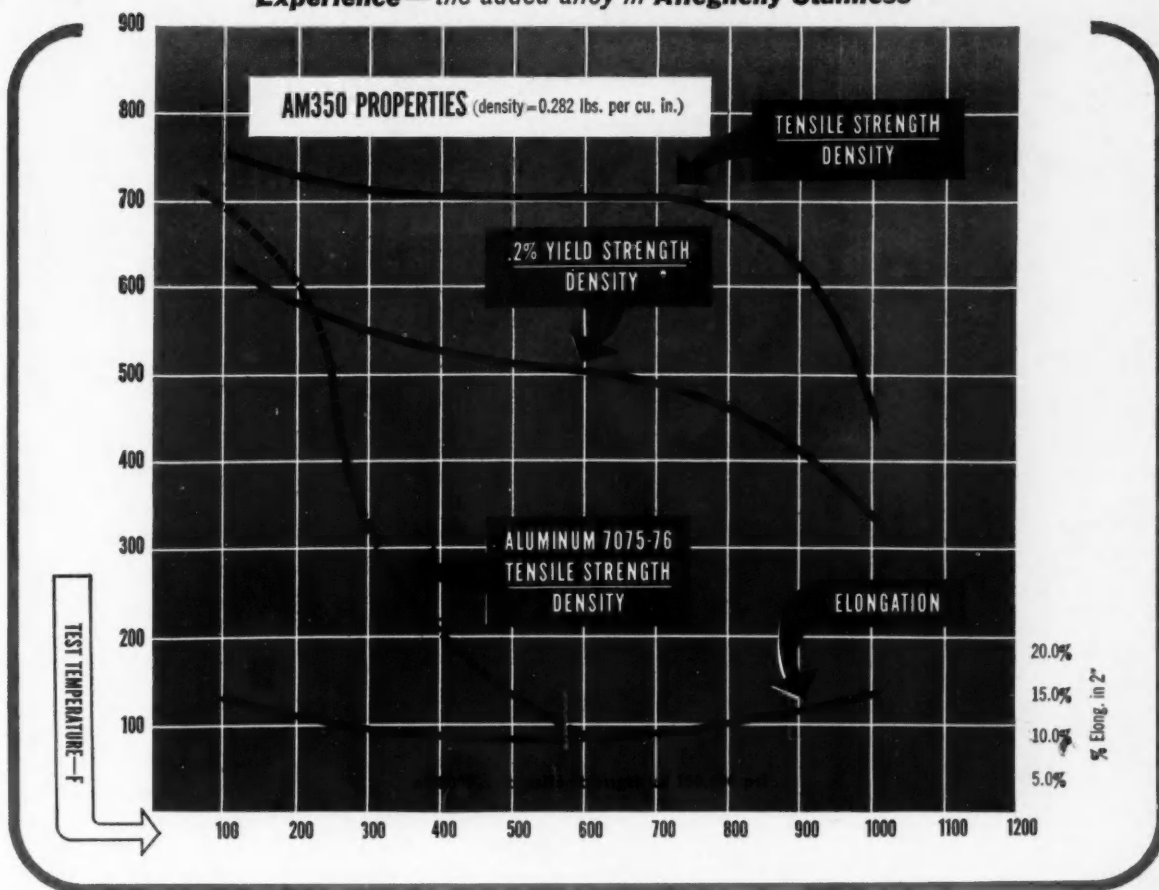
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They are proving the answer to many space age problems. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM-350 and AM-355.

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For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM-350 and AM-355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. SA-17*

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HOW THE SILICONES MAN HELPED... BREATHE MORE LIFE INTO AN OXYGEN MASK

Aboard the new jetliners, oxygen masks are standard emergency equipment. If air pressure in the cabin drops, passengers and crew members can quickly breathe oxygen from a piped system.

Based on experiments by the military, manufacturers know that silicone rubber is the ideal material for oxygen face masks. It provides the thin, elastic shapes needed to fit all facial contours . . . with a gentle lubricity that feels pleasant to the skin. Since silicone rubber is highly resistant to oxidation, ozone attack and extremes of

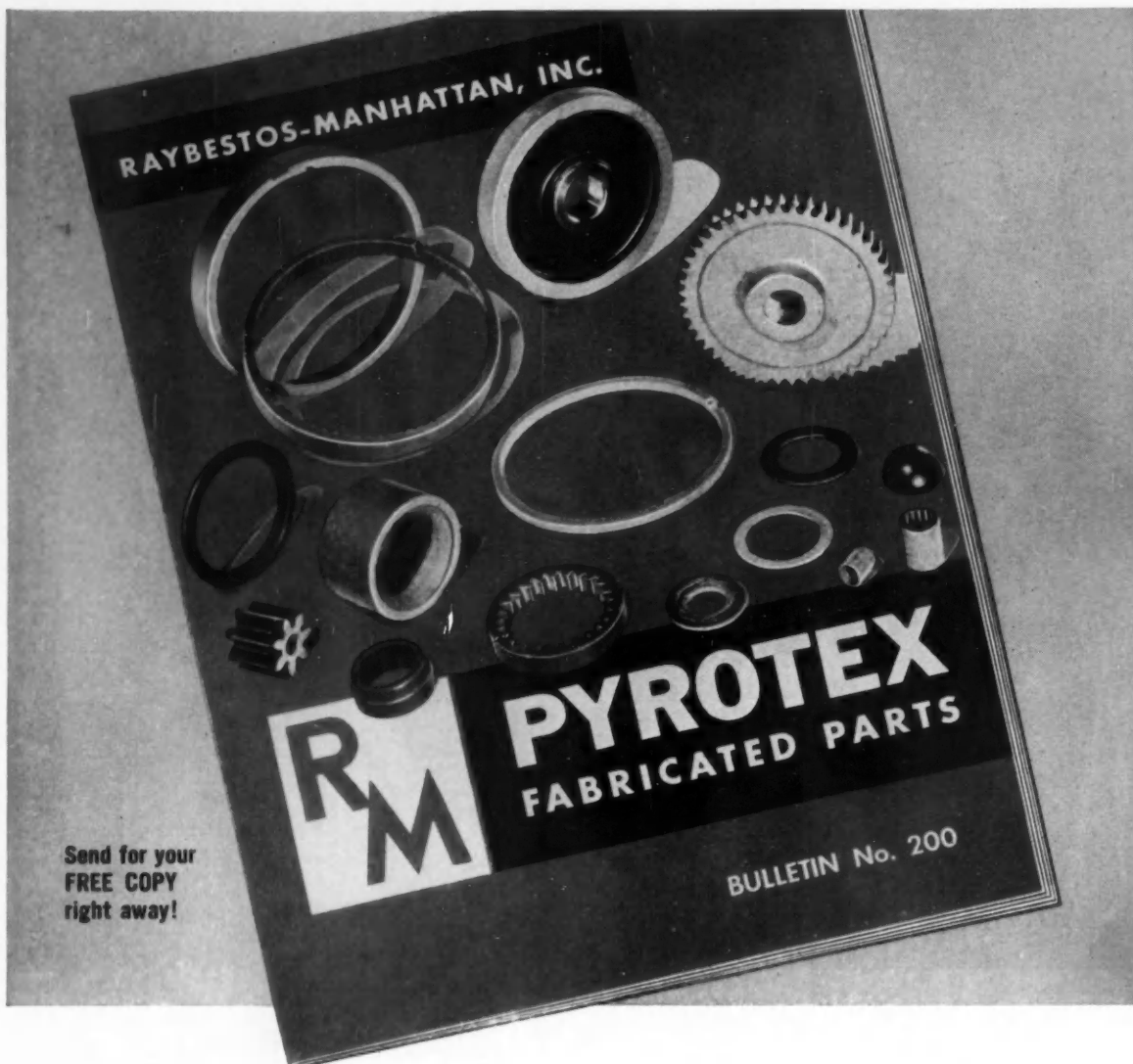
temperature, it can be stored for long periods and take repeated hot-water cleansing. And, any color is available—even "emergency" yellow.

This jet-age application demonstrates several useful properties of UNION CARBIDE silicone rubber. Background information and technical data available by writing Dept. EK-9901, Silicones Division, Union Carbide Corporation, 30 East 42nd St., New York 17, N.Y. In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Toronto 7.

Unlocking the secrets of silicones
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R/M's Pyrotex fabricated parts are economically laminated, molded or machined to rigid specifications. Pyrotex can reduce the cost of many precision parts. An asbestos-reinforced thermosetting plastic, it has a high modulus of elasticity and strength, resists heat, chemicals and water, and has exceptional dimensional stability.

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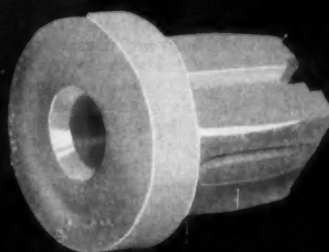
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light
finger pressure
seats it
for good!



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PATENT PENDING



ROUND HEAD



SQUARE HEAD



RECTANGULAR

TABLE OF DIMENSIONS

For use with #8 or #10 screws, finished hole size .290/.281, application thickness .030/.060. Other sizes available soon.

HEAD SIZE	HEAD HEIGHT
7/16" DIA.	.150
1/2" DIA.	.030
1/2" DIA.	.040
1/2" DIA.	.070
1/2" DIA.	.150
1/2" DIA.	.100
3/8" SQ.	.040
3/8" SQ.	.140
13/32" SQ.	.030
13/32" SQ.	.200
3/8" x 37/64"	.060

This new Dot Nylon Push-in Nut offers additional design and performance advantages over our currently available plastic snap-in nuts. These advantages are:

(1) Straight legs permit easy insertion in square, punched holes and do not distort the holes even in soft aluminum or thin-gauge steel. (2) Burrs do not impede the nut or prevent proper seating. (3) Tapered screw hole causes legs to spread when screw is inserted and results in greatly increased pull-out resistance (see drawing A).

Ordinary sheet metal screws cut clean, strong threads in the molded nylon and the nut is both re-usable and highly resistant to vibration.

Used as a nut or as a spacer, Dot's Nylon Push-in Nut has wide application in all products where sheet metals or plastics are employed. They can be supplied with a moisture resistant sealer and special nuts can be designed to your specifications if volume warrants. Currently available in eleven sizes. Full information on request.

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Division of United-Carr Fastener Corp., Cambridge 42, Mass.

MAKERS OF **DOT** FASTENERS

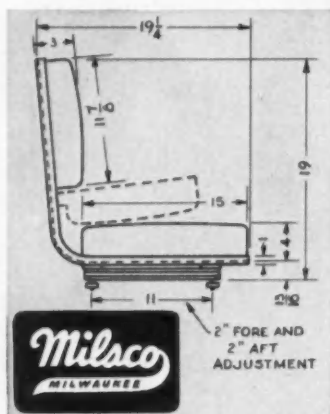
Booth #1026 — Design Engineering Show

Milsco Cushion Seats Custom Designed and Engineered

Outstanding Example Is Smartly Styled "Thrift-King" Seat; Specified And Favored In Every Field of Mobile Equipment

From out of a complete line of over twenty basic models comes this versatile unit in what has been described as

probably the nation's greatest seating value... giving you an unequalled composite of quality with economy.



Over-all dimensions showing relative position of folding backrest.

Featured in the "Thrift-King" Seat is a wide selection of highest quality coverings and eye-styled color combinations. With the almost limitless product development possibilities this provides, your specific seat requirements will be met with Milsco's rare fusion of reality and individuality. No other approach to your problems will assure you of such complete satisfaction throughout every department. This, as well as other Milsco Seats, is available with or without the practically-designed pedestals or risers, for multi-positions and uses. Cushions are heavily padded with several inches of foam rubber for more durable service and operator ease. Other important advantages include such sales-pluses as: exceptionally sturdy, welded angle steel frame, and comfort-curved backrest with optional features for folding convenience.



Pedestal assembly available, with or without fore and aft adjustment.

For illustrated catalog sheet Number 104, which gives a detailed description of the "Thrift-King" Seat, and for

further information on other cushion and contour seating, write, or call

MILSCO MANUFACTURING COMPANY

North 33rd Street

Milwaukee 45, Wisconsin

Phone Hilltop 4-6030



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ECONOMY

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Bendix-Elmira, N.Y.
ECLIPSE MACHINE DIVISION



6 NEW and 11 REVISED Aeronautical Standards & Recommended Practices

were Issued
July 15, 1958

27 NEW and 43 REVISED Aeronautical Material Specifications

were Issued
Aug. 15, 1958

For further information please write

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COMMERCIAL VEHICLE TRANSMISSION MANUFACTURERS IN LANCASHIRE, ENGLAND.

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SAE JOURNAL
485 Lexington Avenue
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Among people who know filters...

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Drivers choose FRAM for quality! U. S. Survey shows: Among drivers who know filters by name . . . more rank FRAM first for quality than any other filter!

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Some Ideas

for your file of practical information on drafting and reproduction
from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find — chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

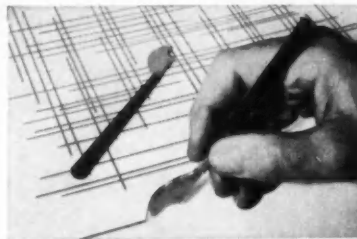
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new — as well as what's tried and true — in drafting equipment.

You'll find many products like these which can be highly useful in your work . . .

K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings—from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will

leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.



Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large

ink supply — draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

An important feature of K&E Marathon Ruling Pens is that they will *not* leak. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch — or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon Wide Line Ruling Pens come in line widths of .030 and .060 inch.

Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.



Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products—small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below . . .

expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed

KEUFFEL & ESSER CO., Dept. SJ-5, Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass ☐ Leroy Height and Slant Control Scriber
☐ Marathon Ruling Pens
☐ Please send me the name and address of my nearest K&E Dealer.

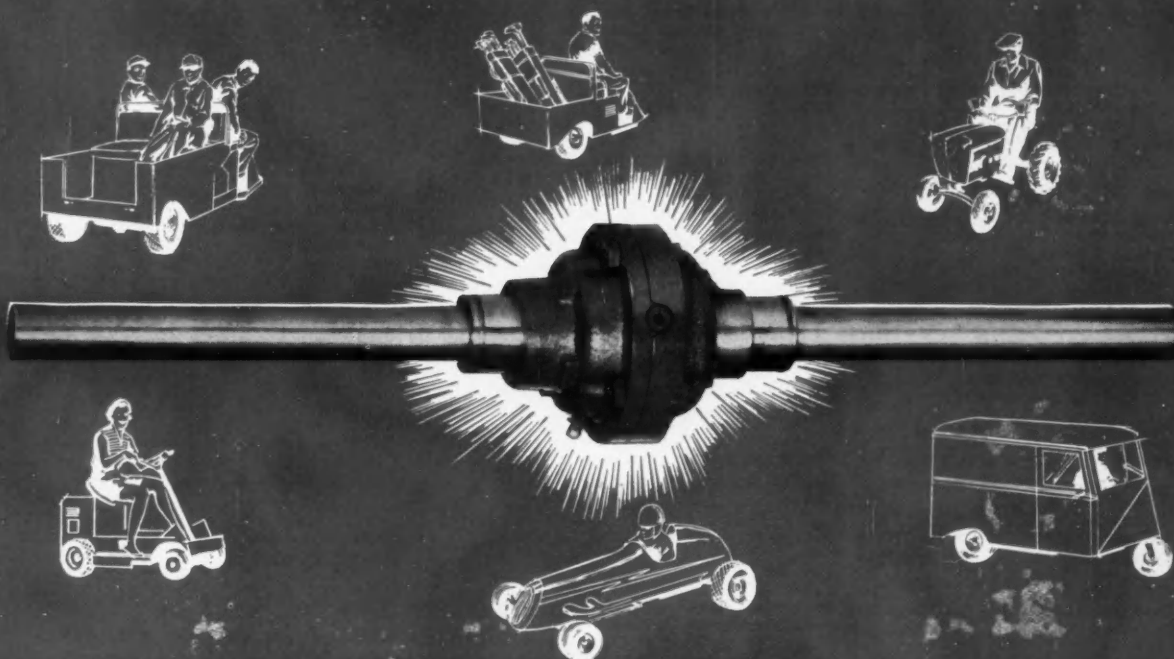
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1613

NEW
from
WARNER AUTOMOTIVE

Compact, rugged DIFFERENTIAL for SMALL VEHICLE* applications



*APPLICATIONS

- Personnel Cars
- Riding Mowers
- Garden Tractors
- Golf Carts
- Small Delivery Vehicles
- 1/4 Midget Race Cars
- Miscellaneous Differential Requirements

Now available in large or small quantities

Here is a compact, new differential assembly with rugged reliability engineered into every detail. Designed especially for small vehicle applications, it is rated at 10 hp . . . has provisions for mounting sprocket, pulley or gears . . . and is furnished with hubs for anti-friction bearings. Hardened alloy steel differential gears and pinions have automotive type cut teeth. Alloy steel axle shafts are readily machinable—or can be furnished machined to your specifications.

Unit is equipped with an Alemite grease fitting for convenient lubrication when mounted externally—or can be run in oil when mounted inside a differential case.

Built to Warner Automotive's traditionally exacting quality and performance standards, this new unit may be the answer to your small vehicle differential requirements. Write for full details, without obligation.



WARNER AUTOMOTIVE

Warner Automotive Division, Borg-Warner Corporation

AUBURN, INDIANA

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Clark simplifies axle machining with DAYTON SEMI-BONDED BUSHINGS

Here's an example of how "Engineering in Rubber," the Dayton way, is used on Clarklift fork trucks. It's a unique viewpoint on the application of sound engineering principles to discover a newer, simpler, more economical way to make rubber do a bigger job for your design.

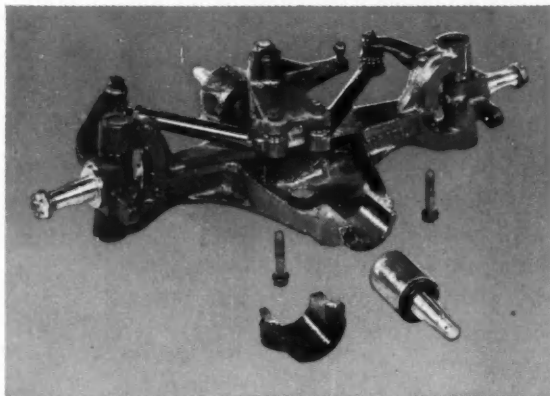
Clark Equipment was doing a good job with the rubber bushings on which the steer axle pivots. But there's always a better way and, working with Dayton engineers, Clark found it.

Look at the results . . . a new Dayton semi-bonded bushing. Delivered ready for assembly, it eliminates a separate bushing cap, an expensive boring operation, plus assembly time before and after machining.

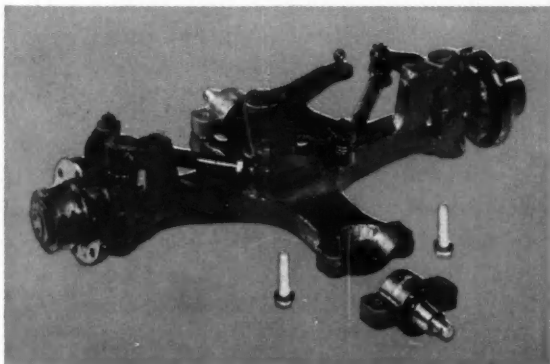
Yet there's no functional difference between this and the older type bushing. Dayton did improve the characteristics by adhering the rubber to the inner metal shaft with a lifetime bonding process . . . reducing the level of pre-compression by nearly $\frac{1}{2}$ in a bushing which must permit up to 3" of articulation in the pivoting axle.

This is what Dayton means by "Engineering In Rubber." It's a design approach that can solve your problems of vibration, shock, and noise control . . . correct inherent misalignment . . . simplify assembly . . . and reduce maintenance costs. The result is better quality at a competitive price.

Fill out and mail the coupon below. It will bring you the prompt, efficient services of a molded products specialist and start you on the way to new savings.



COMPARE THIS METHOD—The conventional way is the more complex way to mount the steer axle to the frame. First the bushing cap must be shimmed and bolted down, the inside diameter bored, the cap disassembled and the shims removed, and the cap replaced again when the bushing is finally installed.



WITH THE DAYTON METHOD—Delivered ready for final assembly, the Dayton semi-bonded bushing is easily bolted into place rapidly and efficiently. Notice, too, how the axle casting has been simplified now that in-line boring is no longer required.

RUBBER RUBBER-TO-METAL RUBBER-TO-FABRIC

Dayton Rubber

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THREE RIVERS, MICHIGAN

I have a design requirement and would like to talk more about it with one of your sales engineers.

Name _____

Company _____

Address _____

City & State _____

KNOW YOUR ALLOY STEELS...

This is the first of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What is an Alloy Steel?

Here is an easy definition to remember: An alloy steel is a grade of steel in which one or more alloying elements have been blended to give it special properties that cannot be obtained in carbon steel.

Or, here is the metallurgical definition: An alloy steel is one in which the maximum specified content of alloying elements exceeds one or more of the following limits—

Manganese, 1.65 pct; Silicon, 0.60 pct; Copper 0.60 pct

or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized commercial field of alloy steels: aluminum, boron, chromium up to 3.99 pct, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other element added to obtain a desired alloying effect.

As a rule, alloy steel is more difficult to make than carbon steel. There are more elements to be kept within specified ranges and, in general, the ranges of the alloying elements are comparatively narrow; hence the mathematical chances for producing off-heats are correspondingly increased. Moreover, most alloy steels require special reheating and cooling to prevent such

imperfections as flaking and cracking.

Surface imperfections must be removed from the billets by scarfing, chipping, or grinding. More exacting methods of testing and inspection are necessary to insure uniformity.

Where Does It Pay To Use

Alloy Steel?

Generally speaking, it is advisable to use alloy steel when more strength, ductility, and toughness are required than can be obtained in carbon steel in the section under consideration. Alloy grades should also be used where specific properties such as corrosion-resistance, heat-resistance, and special low-temperature impact values are needed.

In some cases it requires considerable study to determine when and how to use a particular alloy steel to advantage in a product. Where there is any problem or doubt concerning its use, Bethlehem metallurgists will gladly give impartial advice on analysis, heat-treatment, machinability, and expected results.

In addition to manufacturing all AISI standard alloy steels, this company produces other than standard analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



NEW SUSPENSION TECHNIQUES REQUIRE

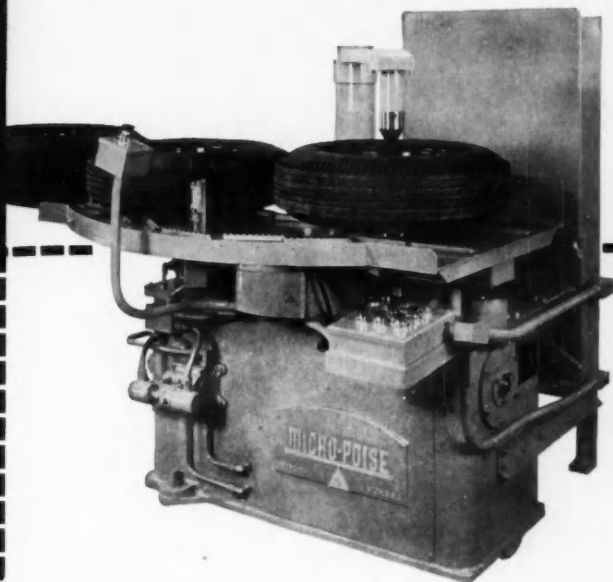
Production WHEEL BALANCING

The merits of well balanced tire and wheel assemblies have long been recognized in the manufacture of luxury cars.

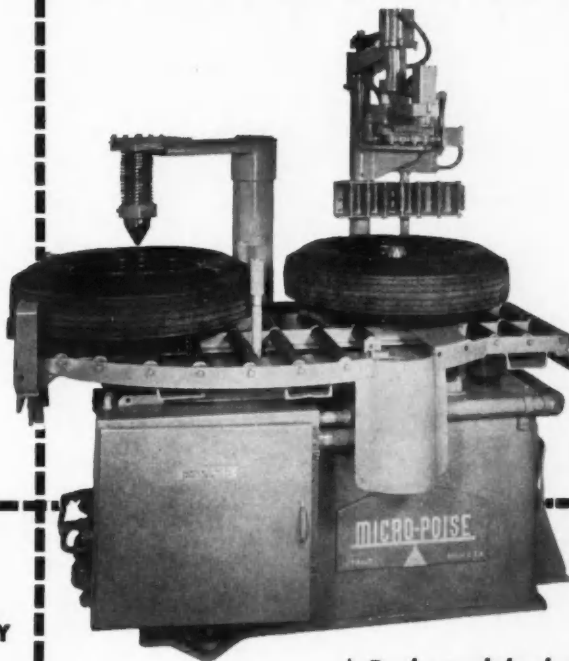
Now new and better suspension methods have pointed up the need for good wheel balance in *all* cars.

Two new Micro-Poise balancing machines, developed especially for the high production needs of the automobile industry, are helping manufacturers economically to extend what was once a luxury car feature to high volume models.

★ (Right) Fully automatic machine takes pieces from power conveyor and delivers them back to conveyor balanced and marked for correction in terms of weight and location.



★ (Above) Semi-automatic machine takes pieces from a power conveyor, balances them and locks them in position while an operator reads unbalance information on a universal level. After he applies the correcting weight the finished piece is returned to the conveyor as the next piece comes into position.



MICRO-POISE

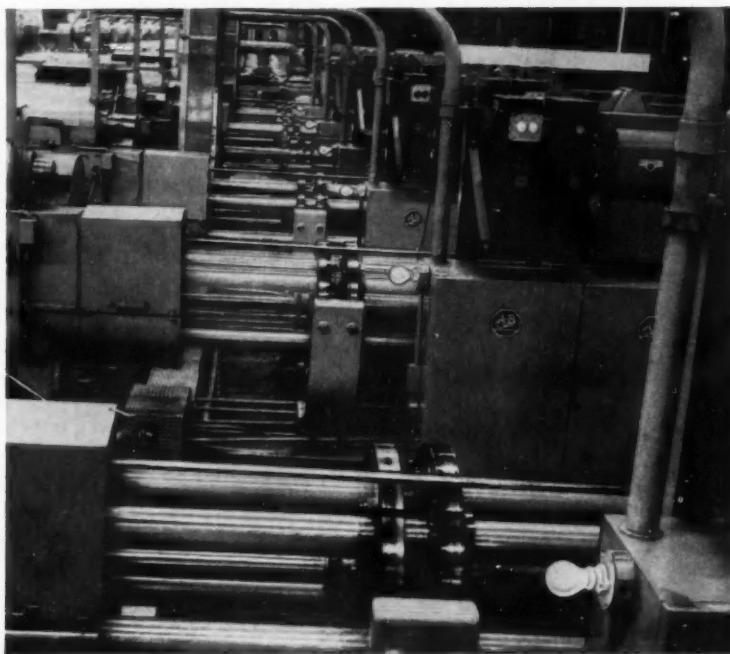
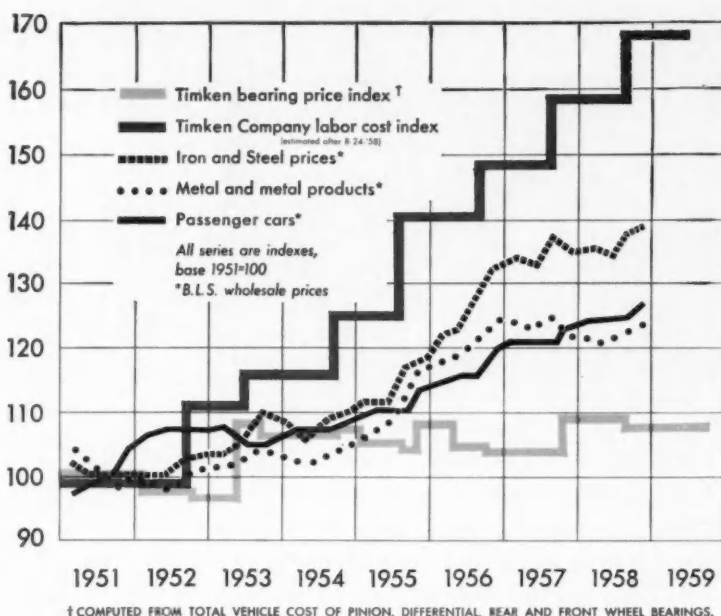
ENGINEERING AND SALES COMPANY

14851 Grand River Avenue
Detroit 27, Michigan

Phone: VERmont 8-1134

★ Both models designed for installation in existing automatic mounting and inflating lines.

You can beat inflation with standardization



YOU almost need a ladder to chart most of your costs, they're going up so fast. But one cost isn't. Timken® tapered roller bearings for passenger cars are staying down low as a new-car silhouette. And that's beating inflation with standardization.

By standardizing on fewer bearing sizes you've kept our new ultra-modern bearing plant in Bucyrus, Ohio (at left) turning out millions of better bearings at lower cost. They're high-speed production "green light" bearings—smaller, lighter, capacity-packed, able to cut costs in related parts, too. Want to create still more savings? Then look for new applications for Timken "green light" bearings (our engineers will help you). And buy more *Timken* bearings made in our cost-cutting plant. The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*



TIMKEN® TAPERED ROLLER BEARINGS

First in bearing value for 60 years